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Biology 30

Population
Dynamics

Module 6



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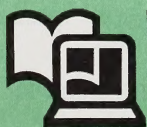
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Biology 30

Module 6

Population Dynamics



**Distance
Learning**

Alberta
EDUCATION

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Biology 30
 Student Module
 Module 6
 Population Dynamics
 Alberta Distance Learning Centre
 ISBN 0-7741-0978-5

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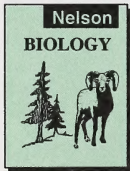
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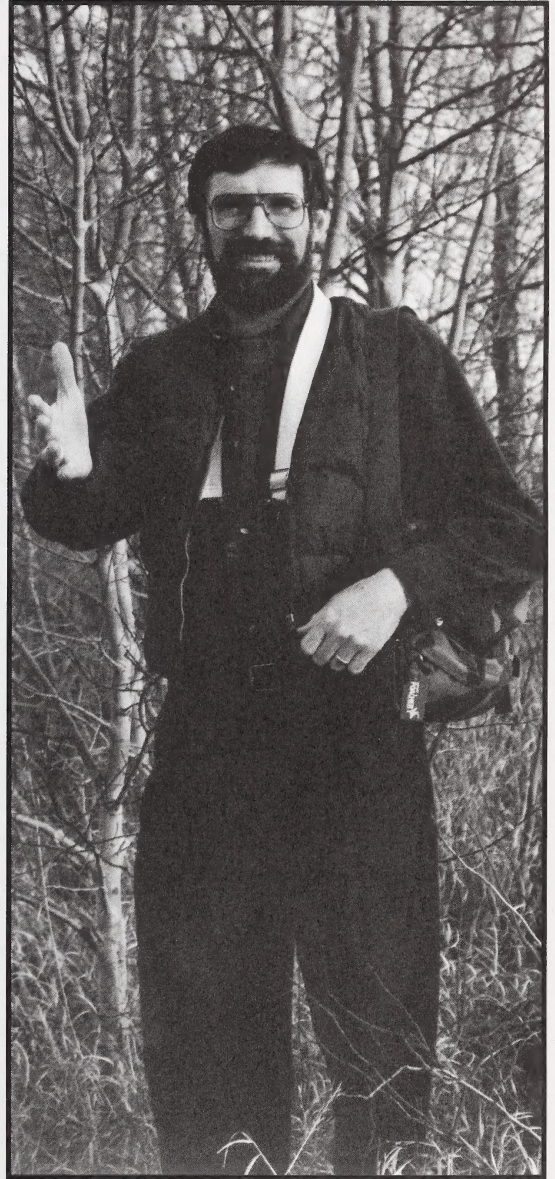
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Welcome to Module 6

We hope you'll enjoy your study of *Population Dynamics*. Remember, to make your learning a bit easier, several videocassettes and laser videodiscs are referred to throughout the modules. Your textbook, *Nelson Biology*, will enhance your studies.



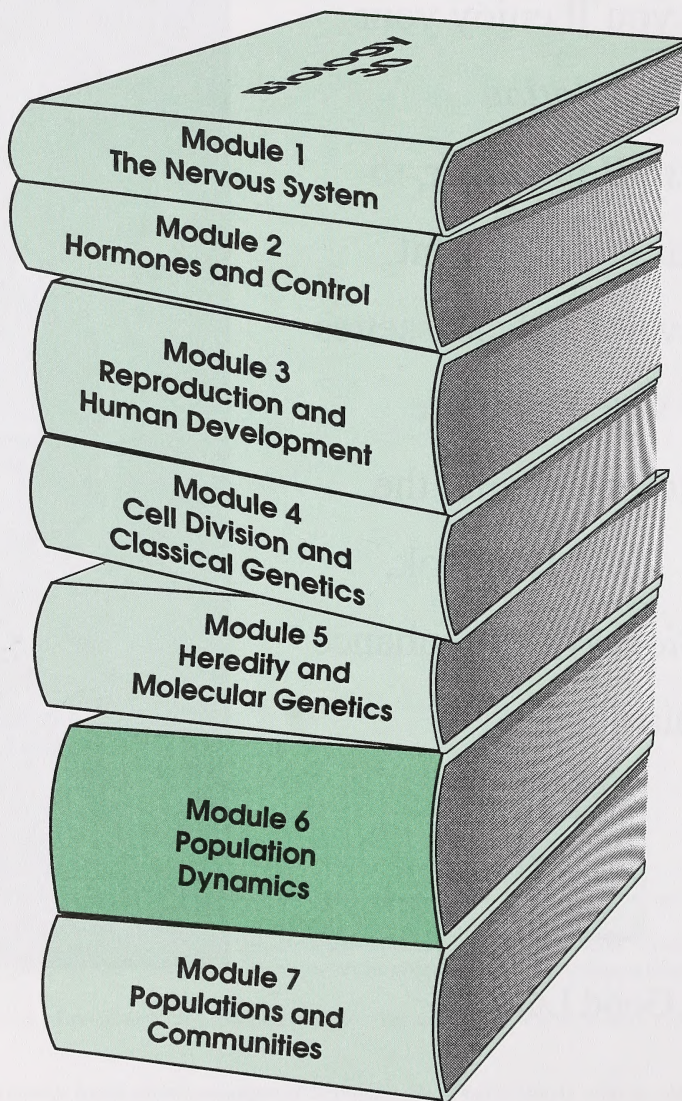
Good Luck!



COURSE OVERVIEW

This course contains seven modules. The module you are working in is highlighted in a darker colour.

Biology 30



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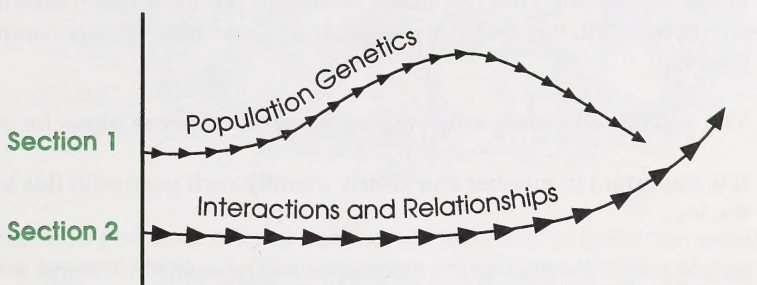
MODULE OVERVIEW

A mountain lion spots a herd of mule deer grazing in a field. The herd is alert as the scent of something different is detected. The new fawns in the herd sensing a potential danger walk over to their mothers. The lion charges the herd. The herd turns and bolts in the opposite direction. One of the new fawns, slightly weaker than the others, falls. The lion, recognizing an easy kill, sets upon the fawn. It's over in a moment. The predator once again kills in order to survive, and the weakest prey once again dies while stronger members survive.

Through this common act of survival, certain genes have been eliminated while others continue. Variation within species has allowed the lion to kill the weakest deer. The basis of variation is due to the genetic makeup of populations.

This module will link the concepts covered in Biology 20 on interactions with the environment and Biology 30, Module 5 on genetics. Examination of how genetics can lead to the development of new species and how the variety of organisms interact with each other will be the focus of Module 6.

Module 6 Population Dynamics



Evaluation

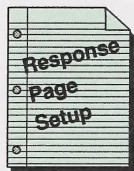
Your mark in this module will be determined by how well you complete the assignments at the end of each section. You must complete all assignments. In this module you are expected to complete two assignments. The mark distribution is as follows:

Section 1 Assignment	55 marks
Section 2 Assignment	<u>45 marks</u>

TOTAL 100 marks

When doing your assignments, work slowly and carefully. If you are having difficulties, go back and review the appropriate section.

Read all parts of your assignment carefully. Plan and do your rough work on your own paper. Revise and edit your responses; then set up your final copy for submission on your own paper. Lined looseleaf is recommended. Make sure your answers are neat and organized, with wide left margins and space for teacher comments after each assignment.



When you see this icon, ideas and details are provided to help you set up and organize your answer in a certain way.

Before submitting your responses, be sure to proofread them carefully to ensure they say what you want, that they are neat and clear, and that they are complete and missing no material.

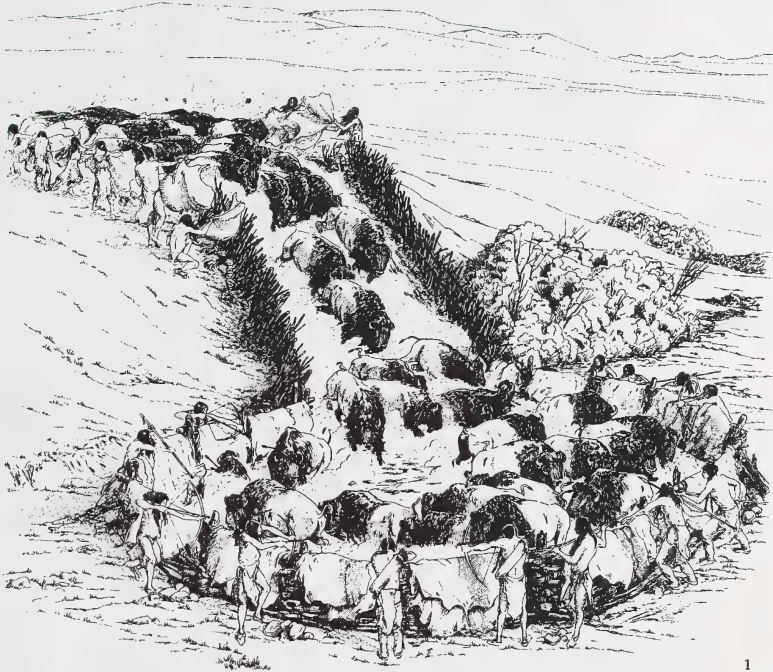
You will be submitting **only** your **assignment response pages** for evaluation.

It is important to number and clearly identify each page with this information placed at the top.

Biology 30 – Module 6 Section # Assignment Page # Name and ID #

Notice that for some assignment questions two marks are given for communication. This is indicated at the end of a question. For two marks your response should clearly and logically answer the question and show strong linkages between cause and effect. Your answer should consist of complete sentences and use appropriate scientific terminology. Diagrams may be an appropriate part of your answer. An answer that requires more than one reading to be understood because it has only weak linkages between cause and effect and contains inconsistencies may only be awarded one mark or less.

Population Genetics



1

The indigenous people of Alberta and Canada were able to live in harmony with the bison that roamed the plains. The bison were important to the lives of the people. When Europeans arrived, they killed thousands of these majestic animals, thus decimating the bison population. This careless destruction nearly led to the extinction of the bison. Fortunately, the slaughter stopped in time and through the work of concerned people, the populations of bison have increased over the past century. Unfortunately, they are still not out of danger for the number and variety of genes within the existing population is small. Not only did the slaughter reduce the number of bison but it reduced the size of the gene pool. It was a genetic slaughter as well.

In this section you will discover why the number and variety of genes in a population is important to the continuation of a species. You will predict gene frequencies using the Hardy-Weinberg equilibrium principle. To complete the section you will look at the significance of ecological reserves in preserving Alberta bison and other gene pools.

¹ From an original drawing by Judith Nicoll for Alberta Community Development.

ACTIVITY

1

The Changing Gene Pool

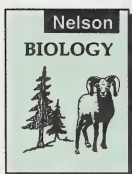


SCOTT CAMERON
ELK ISLAND NATIONAL PARK

The variation among different organisms is vast, and even within the same species some variation exists. This variation, caused by genes, is apparent in the preceding picture of bison. These bison will pass on their characteristics, along with their variations, to their offspring. In Module 4 you discovered how characteristics were passed on from generation to generation. You should also recall from Biology 20 how variations within a population will allow for adaptation and for evolution to occur.

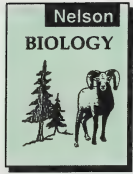
To introduce you to the importance of variation and how to view genes from within populations, read pages 556 and 557 in your text; then answer the following questions.

1. Explain how Darwin's book *On the Origin of Species* would have been complemented by Mendel's work on genetics.
2. Explain the three key ideas of the modern theory of evolution.
3. Why is **biodiversity** considered the Earth's most valuable resource?



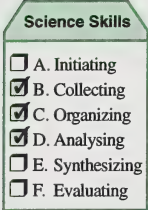
biodiversity –
the maintenance
of the variety of
living things in
the biosphere

Check your answers by turning to the Appendix, Section 1: Activity 1.

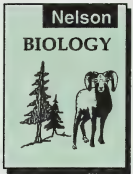


Find at least ten people willing to assist you in the following study. Ask each of them to roll their tongue as seen in the picture on page 557 of your text. Record the percentage of your sample that is able to do this.

4. How does your sample group correlate to the estimated global percentage? Why might the percentages be different?
5. If you tested tongue rolling among family members you might have observed that most of you were the same, possibly even all of you. Why would this be?



Examine the Case Study on page 558 in your text. Notice where hemophilia first appears on the pedigree chart and enters the population. Pedigree charts provide you with a link between genes, inheritance, and the principles of population genetics which you will discuss in this activity.



Natural selection within populations can also be linked back to previous studies in biology. To review natural selection and adaptation, read pages 108 to 112 from Chapter 4; then answer the following questions.

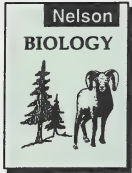
6. Which parts of Darwin's theory relates the closest to the concepts you are exploring in this activity? Explain.
7. Identify three forms of adaptation and describe an example of each form.

Check your answers by turning to the Appendix, Section 1: Activity 1.

Variations Within Populations



Lamarck proposed the hypothesis of acquired characteristics where an organism's needs guided the change in characteristics. One example is the long neck of a giraffe.



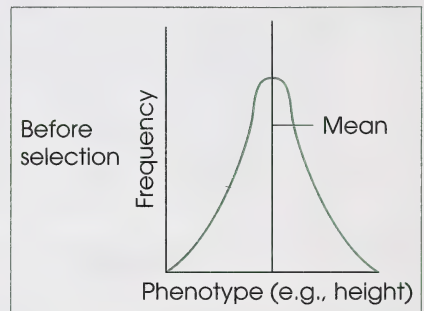
Today it is believed that adaptations don't just occur when the need arises as Lamarck suggested. Darwin stated that the variation that appears must **already exist** in the population. If a suitable variation does not exist when a need arises, the species may become extinct. Needs could arise as a result of changes in environment or competition. Darwin was unable to explain the source of these variations, but you know that mutations are the cause of variation.

Read page 562 in your text to discover how mutations can allow for adaptation and evolutionary change; then answer the following questions. You may disregard the reference to the Hardy-Weinberg principle until Activity 2.

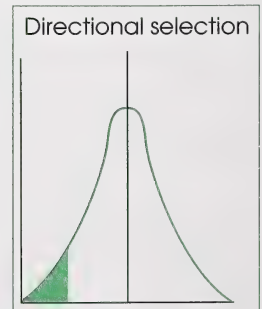
8. Identify the two types of mutations that can occur in an individual.
9. Explain why new mutations are likely to occur in each generation of a population even though mutations are rare events for the individual.

Check your answers by turning to the Appendix, Section 1: Activity 1.

Evolutionary change because of natural selection can result in a number of different ways. One way to recognize selection within populations is through graphical means. The graph on the right illustrates how a population is divided on the basis of the phenotype of height. The frequency describes the relative numbers of organisms for the varying heights. The mean value is the average height of the population. On the far right side, where the individuals would be tallest, they are very few in number. Similarly on the far left side, there are very few short individuals.



You will now examine three types of selection that can occur in populations. Graphs can be used to illustrate how selective forces result in changes in a population. The first type of selection is **directional**. In this population one extreme is selected against, which causes a change in the mean of the population because a portion of the population has died. Examine the graph on the right; then answer questions 10 and 11. The shaded portion in all the graphs indicates the portion of the population that is selected against. Selection against a portion of a population might occur if a mutation was disadvantageous. Imagine a plant whose flowers bloom too early or too late in a season or an animal whose coat colour makes it slightly more visible to predators. Individuals showing these traits would be selected against and perish.



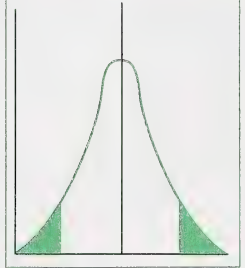
Science Skills

- ☐ A. Initiating
- ☐ B. Collecting
- ☐ C. Organizing
- ☒ D. Analysing
- ☒ E. Synthesizing
- ☐ F. Evaluating

10. If directional selective forces, as shown in the preceding graph, acted upon a population over a long period of time, sketch a graph to show how the new population would be divided on the basis of phenotype.
11. Give an example of an organism that might have undergone directional selection and describe what the selection pressure might have been.

The second type of selection is **stabilizing**. Here forces select against both extremes in the population. The population will now lose the extremes causing the mean to have a higher frequency. Examine the graph on the right; then answer questions 12 and 13.

Stabilizing selection



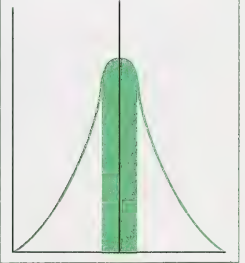
Science Skills

- ☐ A. Initiating
- ☐ B. Collecting
- ☐ C. Organizing
- ☒ D. Analysing
- ☒ E. Synthesizing
- ☐ F. Evaluating

12. If stabilizing selective forces acted on a population for a long period of time, predict how the new population will be divided up by sketching a new graph.
13. Give an example of an organism that might have undergone stabilizing selection and describe what the selection pressure might have been.

The final type of selection is **disruptive**. In this case some force is selecting against the mean of the population. This will cause the frequency of the extremes to increase which disrupts the normal distribution. Examine the graph on the right; then answer questions 14 and 15. This is not a particularly common type of selection, but imagine the case where a foreign species such as the European starling is imported and begins to displace a native bird such as the mountain bluebird in competition for nest sites.

Disruptive selection



Science Skills

- ☐ A. Initiating
- ☐ B. Collecting
- ☐ C. Organizing
- ☐ D. Analysing
- ☒ E. Synthesizing
- ☐ F. Evaluating

14. If disruptive selective forces acted on a population over a long period of time, predict how the new population will be divided. Sketch a new graph to illustrate your prediction.
15. Give an example of an organism that might have undergone disruptive selection and describe what the selection pressure might have been.

Check your answers by turning to the Appendix, Section 1: Activity 1.

Nelson
BIOLOGY



As you have discovered, the genes within a population can change or evolve. This evolution, however, does not always lead to a new species. Read pages 571 to 573 in your text to learn how speciation can occur; then answer the following questions.

16. Define the term *speciation*.
17. Explain why speciation and the concept of Darwinian natural selection are not always closely linked.
18. What have scientists determined as the best definition of a species?

If two groups are geographically isolated, there is obviously no way that they can get together for reproduction. Therefore, these two groups are also reproductively isolated.

19. Hypothesize how geographic isolation could occur in a species of mice living in a farmer's field and explain how two distinct species might develop.

Science Skills

- ☒ A. Initiating
- ☐ B. Collecting
- ☐ C. Organizing
- ☐ D. Analysing
- ☐ E. Synthesizing
- ☐ F. Evaluating



DUCKS UNLIMITED

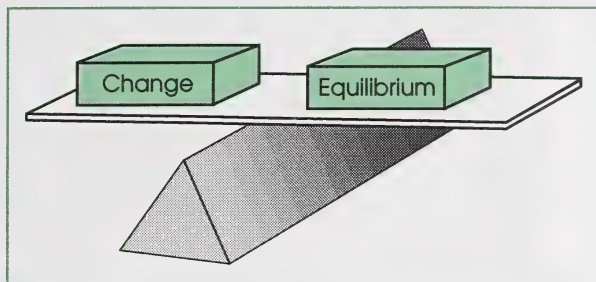
20. If the physical barrier is removed after sufficient time to produce two species, what are the various ways that reproductive isolation might still be in effect?

Check your answers by turning to the Appendix, Section 1: Activity 1.

From your exploration in this activity you should now understand the relationships that exist between genetics and the evolution of gene pools within a species. You should also understand how natural selection and other forces might lead to the development of new species. Scientists know that populations tend to remain stable while at the same time competition forces variability. In the next activity you will explore how populations will tend to remain stable if all factors in the environment and in the population remain constant.

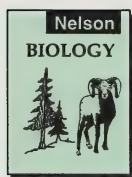
ACTIVITY

2 Hardy-Weinberg Equilibrium



The science of determining whether a species has or is undergoing changes can be quite complex and even controversial. One scientist might hypothesize that a species has undergone significant changes over the past few millennia, while another has the view that there have been no significant changes. It would be beneficial to all concerned if there were a model that could be used to determine whether significant evolution has occurred or not.

The Hardy-Weinberg principle is an important mathematical model to help determine if a population is remaining the same (genetically balanced) or undergoing some type of evolution (unbalanced). The mathematical equation in the Hardy-Weinberg principle presents a picture of the makeup of a gene pool. It shows the percent of each of two genes for a specific trait present in a population. In this activity you will discover how to apply the mathematics of the Hardy-Weinberg equation to a number of situations.



To learn the mathematical relationship of the Hardy-Weinberg principle and to understand what assumptions are required for the equation to be useful, read the first column and a half of page 560 of your text and then answer the following questions.

1. State the Hardy-Weinberg principle in your own words and relate it to the term *gene pool*.
2. What term is used to describe a population's gene pool that remains the same generation after generation?
3. If a population is not in genetic equilibrium, what must be occurring in the population?
4. Write out the Hardy-Weinberg mathematical equation and state what each letter represents.

5. What is the Hardy-Weinberg equation very useful in calculating?

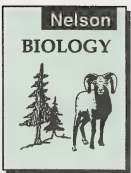


W.J. SCHICK, ELK ISLAND NATIONAL PARK

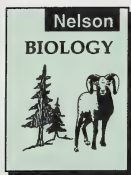
In order for the Hardy-Weinberg principle to function, all conditions within the population and the environment must remain constant. The gene pool must also remain constant or be in equilibrium. A change in the gene pool means natural selection is occurring or, if the changes are drastic enough, causing speciation to occur. The Hardy-Weinberg principle can be used to determine if evolution is occurring.

6. Summarize the five conditions under which there will be no change in the gene pool, or in other words, genetic equilibrium is maintained.

Check your answers by turning to the Appendix, Section 1: Activity 2.



Before going any further, carefully read Example 1 on page 561 of your text. Notice that if you know the frequency of the homozygous recessive phenotype, you can find the heterozygous and homozygous dominant frequencies. One use of the Hardy-Weinberg equation, then, is to determine the percentage of a population having specific genotypes, once the frequency of one genotype is known. This is useful in studies of genetic diseases.



You should now be able to identify the main idea behind the Hardy-Weinberg principle which is to use a mathematical formula to either determine genotypic frequencies or determine allele frequencies. The real power behind the Hardy-Weinberg formula comes in its application for determining what percentage of the population might carry a harmful gene or if a **population is evolving**. Your task now is to learn how the Hardy-Weinberg formula can be applied. Read the rest of page 560 and 561 of your text and answer the following questions.

7. When using the Punnett square with the Hardy-Weinberg formula, what do the eggs and sperm represent?
8. From the explanation on page 560 about allele A and a , determine what the genotype frequencies will be in the second (F_2) generation if two heterozygotes from the F_1 are mated. Show your work.

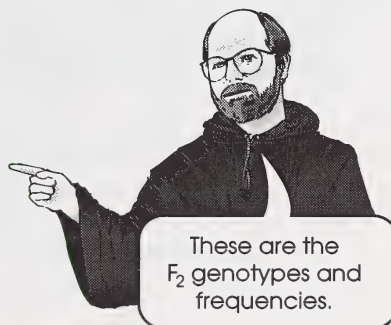
Science Skills

- ☐ A. Initiating
- ☐ B. Collecting
- ☐ C. Organizing
- ☒ D. Analysing
- ☐ E. Synthesizing
- ☐ F. Evaluating

Check your answers by turning to the Appendix, Section 1: Activity 2.

You can use a Punnett square to find the answer to question 8. The F_1 genotype is Aa . Gametes will be A and a . A has a frequency of 70% or 0.7 out of 1 in the F_1 of this population. The a allele has a frequency of 30% or 0.3 out of 1. Set up your Punnett square like the following one and combine the alleles to find the F_2 genotypes.

		A	a
		0.7	0.3
A	0.7	AA 0.49	Aa 0.21
a	0.3	Aa 0.21	aa 0.09



Add 0.21 plus 0.21 to get 0.42 for the heterozygous frequency.

You can also use the Hardy-Weinberg equation to find the frequency of the F_2 genotypes.

$$\begin{aligned}
 p^2 + 2pq + q^2 &= 1 \\
 (0.7)^2 + 2(0.3)(0.7) + (0.3)^2 &= 1 \\
 0.49 + 0.42 + 0.09 &= 1
 \end{aligned}$$

In humans there is a blood antigen system known as the MN system. It is different from the commonly known ABO system that is important for blood transfusions. MN blood antigens will not cause agglutination if mixed as the ABO antigens could. The observed allele frequencies in the population are $M = 60\%$ and $N = 40\%$.

Science Skills

- ☐ A. Initiating
- ☐ B. Collecting
- ☐ C. Organizing
- ☒ D. Analysing
- ☐ E. Synthesizing
- ☐ F. Evaluating

9. Use the Hardy-Weinberg principle to determine the genotypic proportions of the M and N antigens in the population, assuming genetic equilibrium applies. Let $p = M$ and $q = N$. Also remember $p^2 = MM$ the homozygous dominant genotype; $pq = MN$, heterozygous; and $q^2 = NN$, homozygous recessive.

Check your answers by turning to the Appendix, Section 1: Activity 2.

By using the information in question 9 regarding the allele frequencies in the entire human population, you can determine if, for some reason or another, a selected population is undergoing change by studying the frequency of its genotypes. To show this, complete the following question.

Science Skills

- ☐ A. Initiating
- ☐ B. Collecting
- ☐ C. Organizing
- ☒ D. Analysing
- ☐ E. Synthesizing
- ☒ F. Evaluating

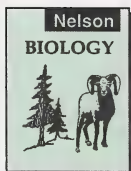
10. These MN blood types were found in a northern Alberta town of 200 people.

$MM = 52$ people $MN = 96$ people $NN = 52$ people

Determine if there has been changes in allele frequencies and what might be the cause of these changes (if any). Compare the frequency of the genotypes in this population to the frequencies in the "normal" population in question 9. Keep in mind the M is the allele represented by p in the equation and N is represented by q .

Check your answers by turning to the Appendix, Section 1: Activity 2.

How would you know if the discrepancy found in question 10 was significant enough to make a hypothesis that natural selection might be occurring in a remote community? To answer this and other problems regarding the Hardy-Weinberg principle, statistics are commonly used to determine if a population is actually changing or if the change is due to some random factor. The probability of change occurring can be analysed using the chi-square test. You can learn more about this statistical analysis in the Enrichment activity of this section.



If you are not yet comfortable with the Hardy-Weinberg principle, go back to your textbook and review pages 560 and 561. If you are comfortable in your knowledge, move on to the Case Study to analyse two genetic disorders as models for reviewing the Hardy-Weinberg principle as it relates to evolution. Read the Case Study on Sickle-Cell Anemia on pages 567 to 568 carefully and answer the following questions.

11. Do textbook questions a to g.

Check your answers by turning to the Appendix, Section 1: Activity 2.

The genetic disorder of sickle-cell anemia is a model for studying evolution in human populations. The heterozygous condition exhibits positive characteristics in the ability to resist malaria and thus affects human survival. Another genetic disorder that can act as a model to study evolution is Tay-Sachs disorder.

Read the remainder of the Case Study on pages 568 and 569 of your text and answer the questions on Tay-Sachs that follow.

12. Do textbook questions h to n.

Check your answers by turning to the Appendix, Section 1: Activity 2.

This case study has allowed you to link a number of concepts in Biology 30: the concepts of mutation, protein synthesis, heredity, genetic variation, evolution, and immunity. To finalize your analysis of this activity, answer the Case Study Application Questions found on page 569 of your textbook.

13. Do textbook question o and Application questions 1 to 3.

Check your answers by turning to the Appendix, Section 1: Activity 2.

The Hardy-Weinberg principle has made it easier to understand why genetic variation is maintained and allows scientists to evaluate whether a population is undergoing evolution. Variation as you know is extremely important to the well-being of any population. Populations need variation to cope with changes in their environment. Unfortunately, some environmental changes, such as ones caused by human activities, can be too rapid for many organisms to adjust to. The next activity will allow you to further explore how a species native to Alberta was almost lost.

ACTIVITY

3

Ecological Reserves

How many species of living things are there on the planet? The best answer is that no one knows. Estimates have been made from 5 000 000 to 20 000 000. From your previous studies, you should understand what a species is and how it arises. As human activities very often alter or destroy habitat, many species have become endangered, eliminated from some regions, and finally extinct. This represents the destruction of a gene pool. Can you name some species that this has happened to? Are there any species at risk in Alberta that you can think of?

ecological reserve – habitat set aside in perpetuity to preserve a representative ecosystem

Attempts have been made to remediate the decimation of some species such as the bison and the swift fox. Some of these populations have been saved by the creation of **ecological reserves**. Do you know what an ecological reserve is? Is it different from a wildlife park? In this activity you will explore the ecological reserve program in Alberta, and outline the major reasons why biodiversity must be maintained. In conclusion, you will write a position paper that supports your point of view on a controversial issue.



COURTESY OF C. MAMO,
CANADIAN WILDLIFE SERVICE

There is a tremendous amount of effort being undertaken by people in the province to protect ecosystems from destruction. SPECIAL PLACES 2000 is the name of the government program to identify and protect examples of all major ecoregions within the province. The United Nations has a world-wide goal to set aside 12% of all regions for eternity. The purpose is to maintain biodiversity and provide adequate amounts of habitat to prevent extinction. To gain a more complete understanding of this issue, read the following essay on biodiversity. When you are finished, answer the questions that follow the article.

Notice as you read the article that whole ecosystems are considered important for protection. In the past it was common to note the condition of particular highly visible species like bison and to work to prevent their extinction. There was nothing wrong with this approach for the species concerned, but often the true problem was not recognized. While the effort to save a single species is admirable, your recent studies should make you aware of the importance of saving entire ecosystems. Look at it this way. There is no sense in saving the swift fox if it has no place to live. Its habitat must be saved as well. In addition, if an ecosystem is preserved to give one particular species a place to live, many other organisms will be preserved as well. Try and visualize any organism within its particular niche. Notice how the niche is obviously a part of the larger ecosystem. By preserving an entire ecosystem, many niches and their organisms can be preserved as well. Now you are thinking like an ecologist.

Biodiversity

by Joyce Gould and Peter Lee, Natural and Protected Areas

The term “biodiversity” is one of the latest buzz words being tossed around through the print and electronic media, but what does it really mean?

Biodiversity is really a short form for biological or biotic diversity. It is technically defined as, “the structured and functional variety of life forms at genetic, population, species, community and ecosystem levels.” It sounds simple enough, but why all the attention?

The Importance of Biodiversity

The essence of the biodiversity message from the experts is an urgent warning that even though species “naturally” go extinct and ecosystems “naturally” change (as part of the evolutionary process), the rates of extinction and ecosystem change that have occurred during the last 65 million years (since the dinosaurs’ age) are small in comparison to the escalating rates predicted for the coming decades. The experts also predict this escalation will have enormous negative impacts on our earth and on the human species.

The role of any one species in the ecosystem is complex and poorly understood. Several species may perform the same ecological function (i.e., primary producer) but one species may be better suited to perform that function under different environmental conditions. The loss of one species from an ecosystem will not necessarily lead to the collapse of that ecosystem. However, certain species are “keystone” species. That is, they influence the survival of several other species. These species are critical to the functioning of the ecosystem. The problem is, we do not know which species are keystone. Thus, all species should be considered critical in the functioning of the ecosystem until such time as their absence has been determined. This can be done only through long-term observation and experimentation and through a complete understanding of the functioning of the ecosystem.

The diversity of a species’ genetic composition dictates how the species interacts with its environment and how it responds to human-caused disturbances. Diversity is raw material for evolutionary change. Without the evolution of species, populations and ecosystems, the ability of future generations to survive is diminished. This ability is particularly important in light of human-induced changes such as climate change.

Ecosystems are dynamic systems – they experience wide variations in species composition over time (i.e., successional changes) yet function normally. It is important not to keep ecosystems at any

one state, but to allow them to function normally over time.



Reasons for maintaining biodiversity have been summarized in *Looking Ahead: A Wildlife Strategy for Ontario* (p. 41) as:

- to keep all options open;
- to fulfil our obligation to future generations to pass on as complete a world as possible;
- to retain recognized and, as yet, undiscovered values and uses of wildlife;
- to protect unknown and hidden interconnections and dependencies which exist in ecosystems, especially with respect to maintaining the integrity of food-webs;
- to minimize the risk of destabilizing ecosystems through the loss of species of genetic diversity;
- to retain genetic diversity, and
- to preserve the capacity of all species to evolve.

Maintaining Biological Diversity

Habitat loss and degradation are the primary threats to the loss of biodiversity. To maintain biodiversity, adequate habitat must be ensured for

all species and must be large enough for species to be able to sustain themselves indefinitely. A diversity of habitats and ecosystems must be preserved to ensure the long-term maintenance of species and genetic diversity.

Managing for Biological Diversity

Managing for biological diversity requires an ecosystem approach. However, our knowledge of ecosystem structure and function is incomplete, so we must first strive to collect pertinent information. The ecosystem approach will require ways of housing data and information, improving the monitoring of the effect upon ecosystems of management activities and other human-induced changes (i.e., climate change), and ensuring there is an adequate representation of the various ecosystems found within protected areas in the province. The protection of rare, threatened and endangered species is also important in the maintenance of biodiversity.

The Biodiversity Convention was one of the major products that emerged from the June 1992 United Nations Conference on Environment and Development. This convention stressed the importance of conserving biodiversity in natural surroundings. It recommended that each jurisdiction "establish a system of protected areas to conserve biological diversity" and "develop guidelines for

the selection, establishment and management of protected areas to conserve biological diversity."

The preservation of biodiversity is a real challenge. The basic premise for management should be to err on the side of caution. As stated by Aldo Leopold, "the basic rule of intelligent tinkering is to keep all the parts."

Natural and Protected Areas is preparing an information paper on biodiversity which will continue to outline our role in this important issue. If you are interested in contributing your thoughts to this paper or have ideas for topics to be covered, please call Joyce Gould at 427-5209.

Suggested Reading

Ontario Wildlife Working Group. 1991. Looking Ahead: A Wildlife Strategy for Ontario. Prepared for: The Minister of Natural Resources.

Rosey, M. 1992. Saving the Strands of Life: Alberta's Biodiversity. Edmonton: Environment Council of Alberta. ECA92-PA/CS-S18.

Wilson, E.O. (editor). 1988. Biodiversity. National Academy Press, Washington, D.C.

Wilson, E.O. 1992. Biodiversity. Harvard University Press, Cambridge, Massachusetts.¹

Answer the following questions in a sentence format.

Science Skills

- ☐ A. Initiating
- ☒ B. Collecting
- ☐ C. Organizing
- ☐ D. Analysing
- ☐ E. Synthesizing
- ☐ F. Evaluating

1. Why has the rate of extinction rapidly increased?
2. Summarize what is meant by the term *keystone species*.
3. Why is diversity important to the long-term survival of a species?
4. Is it possible to maintain ecosystems as they are? Explain.
5. Relate the strategy of establishing ecological reserves to maintaining biodiversity.

Check your answers by turning to the Appendix, Section 1: Activity 3.

¹ The Steward, for the article "Biodiversity," by Joyce Gould and Peter Lee, Natural and Protected Areas, Issue 22, April 1993. Reprinted with permission of Alberta Parks Service.

The next decade will see either great progress in protecting biodiversity or a significant loss of species. In some situations, saving parts of an ecosystem is not enough. To discover how fragmentation or the partitioning of an ecosystem affects organisms, read through the next article; then answer the question that follows.

Fragmentation

Natural ecosystems are traditionally studied as separate entities, e.g., a spruce bog, an aspen forest or a fescue grassland. We now know they are not separate entities, but rather integrated components of the natural landscape. The configuration of the pieces is as important as the makeup of the pieces themselves.

Fragment is a term used to describe a landscape that was once essentially natural but has undergone human-induced change in some way. The effect that this change has on our natural landscape is one that we are only beginning to understand. The Natural and Protected Areas Section contracted Leslie Brown and Robert Wright to review literature about fragmentation and to summarize some of the causes and results. This article summarizes their findings.

The impact of fragmentation on a natural landscape depends on many factors, including distance between fragments, connecting corridors for animal and plant movement, and the size and shape of fragments. Scale is an important factor in measuring the effect of fragmentation. For instance, a fire that burns individual trees or stands of trees in a Natural Area may be devastating to that small site, but overall it could be beneficial in maintaining the natural mosaic of the surrounding area.

Potential impacts of fragmentation can be divided into two main types, barriers to species' movements and edge effects.

Barriers to Species' Movements

When an area is fragmented, individual pieces are essentially "islands" with species separated from the rest of the natural landscape.

As populations of plants or animals become isolated from other populations, there is no longer mixing of populations, resulting in a loss of genetic diversity (inbreeding). The result could be extinction of species within individual fragments. Depending on the species, the size of disturbance need

not be large for this to happen. Some studies have found that disturbances in areas as small as 10 m (33 ft.) for insects and 100 m (328 ft.) for birds can create barriers to movement. Keeping in mind the web of life represented by an ecosystem, the loss or reduction of one species affects others.

One study showed that when insect movement into a site was blocked by a road, there were fewer pollinators and the low pollination rates reduced the reproductive success of insect-pollinated plants.

Edge Effects

The area where a disturbance and natural community meet is called the edge; the edge effect describes how the creation of an edge affects the natural community. Most studies on this have focused on the edge effect created when forests are fragmented by cropland development. Very little is known about the effect on grasslands, wetlands or shrublands, but it is reasonable to assume that there could be edge effects with these communities as well.

In forests, the edge effect can cause potentially disruptive micro-environmental changes in water flow, soil temperature, wind and light. Studies show that increased wind turbulence downwind of cleared areas has resulted in windthrow (blowing over of trees). In addition, one study demonstrated that increased tree-sway reduced nesting success.

An increase in the wind and light at the edge of a forest may create favourable conditions for disturbance-area animals and shade-intolerant plants not previously found in the area, while "interior" species are lost. Often the species favoured by fragmentation of a landscape are opportunistic and their invasion negatively affects resident species. Some studies, for example, have shown that brown-headed cowbirds, a species that parasitizes other birds' nests, and crows (a species that will rob nests) have been favoured by fragmentation. Because of this, the rate of nest predation increases within 500 m of an edge and, combined with nest parasitism, results in a decline in reproductive success of forest-interior birds.

What kinds of disturbances result in fragmentation?

The answer is any disturbance. Roads, especially those over 20 m wide, are effective barriers to movement of insects and small mammals, and will change the microclimate up to 30 m from the road's edge. A study on the impact of a nature trail showed a vegetational disruption 2 m to 3 m wide in understory vegetation. In addition, the trail attracted some of the generalist predators, such as blue jays and brown-headed cowbirds.

Fragmentation is thought to be the primary cause

of the alarming extinction rate of species and the most serious threat to biological diversity. The state of the pieces of the landscape is important, but equally so is the pattern of how those pieces fit together and interact.

Natural Areas are usually quite small and therefore subject to the effects of fragmentation. We must view each site as a core or nucleus within a larger landscape unit, not as an isolated island. What takes place in a Natural Area is important to the surrounding region but, perhaps more importantly, what goes on in the surrounding region is critically important to the Natural Area.¹

Science Skills

- ☐ A. Initiating
- ☒ B. Collecting
- ☐ C. Organizing
- ☐ D. Analysing
- ☐ E. Synthesizing
- ☒ F. Evaluating

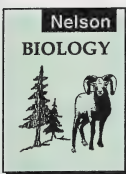
6. Write a paragraph to show why ecological reserves should be as large as possible. Defend your position with information from the preceding article.

Check your answers by turning to the Appendix, Section 1: Activity 3.



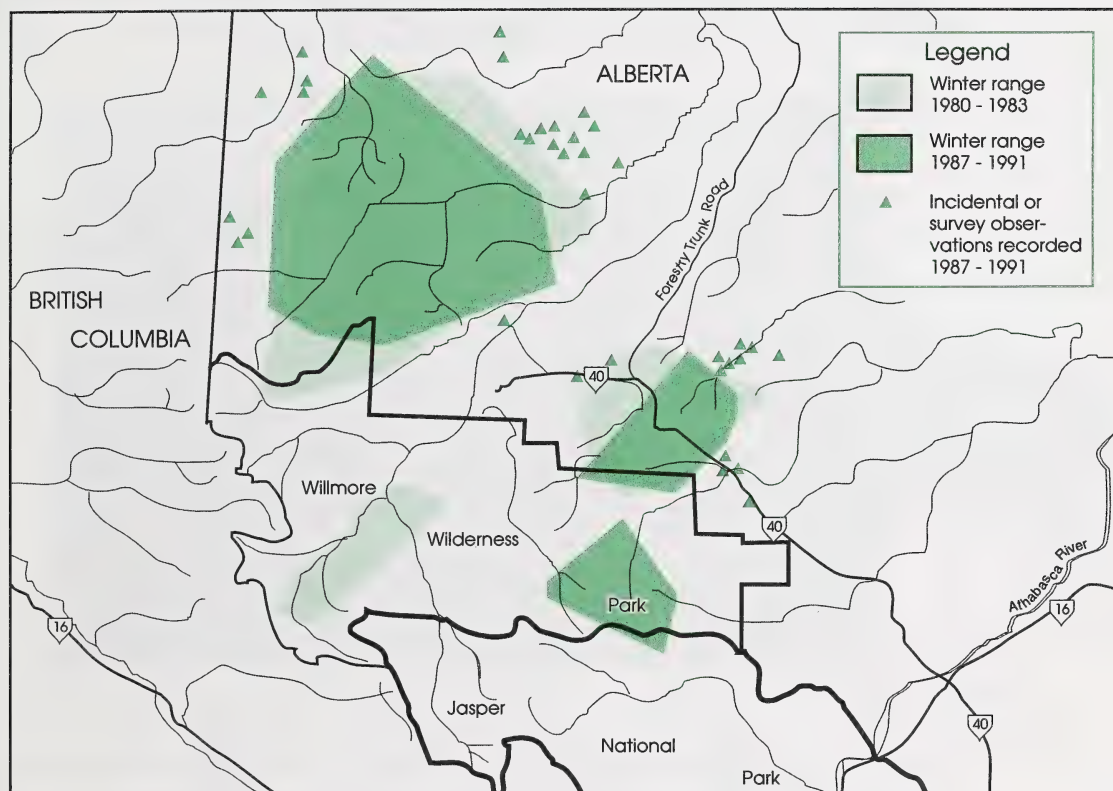
COURTESY OF D. THOMAS
CANADIAN WILDLIFE SERVICE

¹ *The Steward*, for the article "Fragmentation," Issue 17, 1993. Reprinted with permission of Alberta Parks Service.



One of the organisms affected by fragmentation of habitat in Alberta is the mountain caribou. Read the Research in Canada article on page 55 in your text for an overview of a research project. Incidentally, the photograph of caribou on page 55 features barren ground caribou in the Arctic. If you look at it closely, you will see that the photo is upside down. After reading the article, examine the following map and answer the next questions.

Primary Winter Ranges of Mountain Caribou Herds in West Central Alberta



1

Science Skills

- ☐ A. Initiating
- ☐ B. Collecting
- ☐ C. Organizing
- ☒ D. Analysing
- ☐ E. Synthesizing
- ☒ F. Evaluating

7. Describe any changes in the winter ranges of mountain caribou between 1983 and 1991.
8. How might these changes in winter range affect the caribou population?
9. What has happened to the winter range of the caribou in Willmore Wilderness Park?

¹ Draft copy of *Population Status and Winter Distribution of Mountain Caribou in Central Alberta, 1987-1991*. Reprinted with permission of Alberta Department of Environmental Protection.

10. Identify some inconsistencies that may exist in the current data base as the winter range appears to have been abandoned.

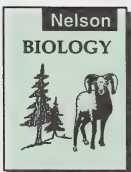
Check your answers by turning to the Appendix, Section 1: Activity 3.

These caribou are now being studied to prevent their loss from Alberta – it may even be too late. Now you are going delve into the history of the greatest plains animal, the bison, which have returned from the brink of extinction.



GREG BELLAND
ELK ISLAND NATIONAL PARK

In Alberta, you can find bison in several places. Some are raised on private ranches and in zoos, while the vast majority live in either Elk Island National Park or Wood Buffalo National Park. There are some structural (morphological) differences between some groups of these bison. Are they a different species or subspecies?



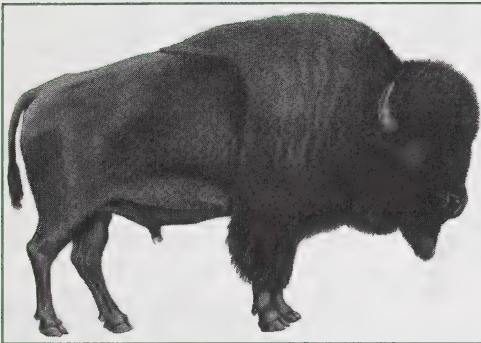
Read the Social Issue on page 574 in your text and the bison information that follows; then answer the following questions.

Notice that the bison in North America were extremely numerous as little as 200 years ago. In less than 100 years, the bison were nearly exterminated. This is an unfortunate example of human actions having a dire effect on another species. Not only have the animals themselves been affected, but, as you will learn, their gene pool has been threatened. As a student of ecology, try and visualize the bison as populations of gene pools trying to survive in an ecosystem. Are all bison alike? Should the bison be saved? What do you think of the statement on page 574?

BISON

Plains Bison, Wood Bison – Which Is Which?

– In Elk Island the plains bison are on the north side of Highway 16 and the wood bison on the south side. (Bulls are used for comparison in the following chart.)



Plains Bison

- Bulls average 730 kg. (Cows, 410 kg.)
 - Shorter neck
 - More rounded hump
 - Smaller and stockier
 - Chaps of long hair on forelegs
 - Cape is usually lighter in colour
- In summer, cape forms distinct boundary with the rest of body
 - Frizzy hair on head
 - Larger more rounded beard



Wood Bison

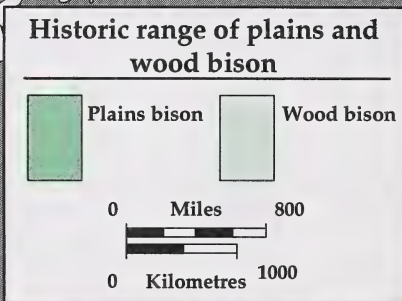
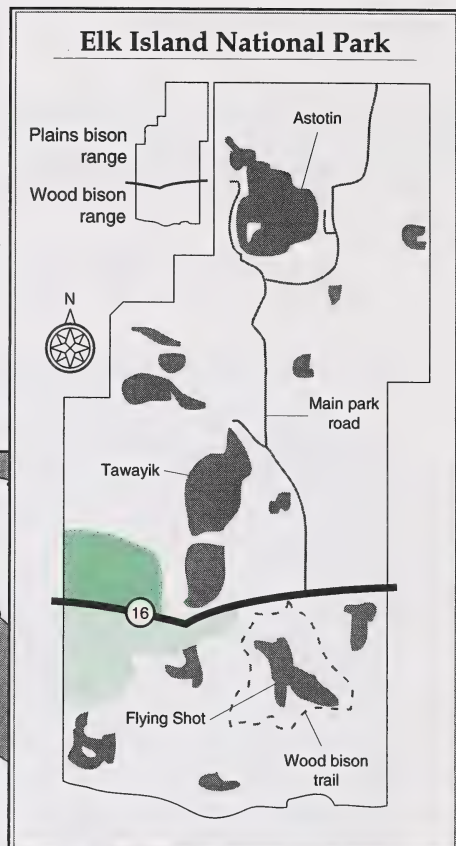
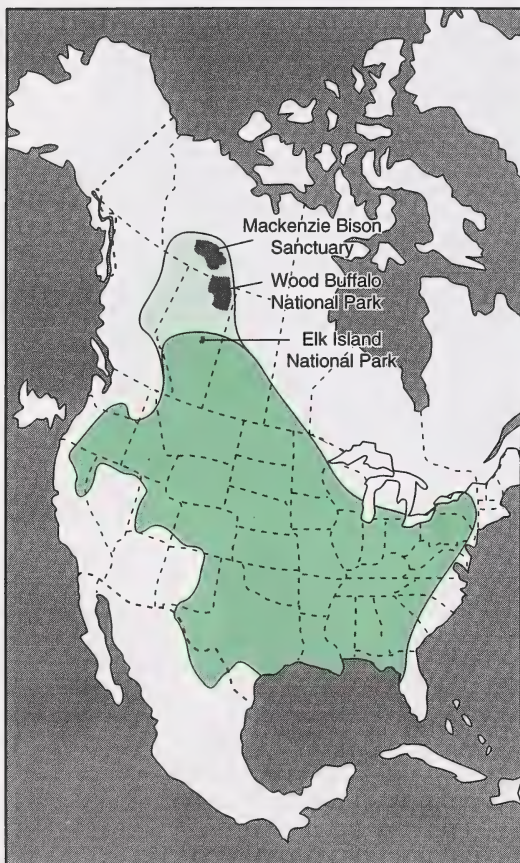
- Largest native land mammal in North America
 - Bulls average 840 kg – 10 to 15% heavier than plains bison (Cows, 475 kg)
 - Taller and squarer hump
 - Darker in colour
- Generally taller and larger
 - Little or no chap hair on forelegs
 - Cape usually does not form distinct boundary with rest of body
 - Long, straight hair, sloping down on forehead
 - Smaller, more pointed beard

Park acts as sanctuary



Elk Island National Park preserves a part of what the Beaver Hills area was like before humans plowed the fields and built the towns that surround it. The park also acts as an island sanctuary for two subspecies of bison that were nearly lost to mankind.

The story of how bison returned to Elk Island is a story of lucky breaks and remarkable events.



Return of the Plains Bison



For 400,000 years, millions of these shaggy animals roamed a vast feeding ground in North America that stretched from Mexico to northern Canada, from the Rocky Mountains to the Atlantic sea-board.

It took less than a century to bring this impressive beast to the brink of extinction.

Plains bison had been hunted for hundreds of years by native people. It is estimated that more than 60 million plains bison roamed North America in the 1700s, a seemingly endless source of meat and hides. Introduction of the horse and rifle combined with additional pressure from hide hunters to ravage the population. By 1880, only a few hundred plains bison were left.

The return of the plains bison to the Beaver Hills area (Elk Island) of Alberta came in 1907. The Canadian government bought the world's largest remaining herd (716 bison) from a Mexican-born rancher, Michel Pablo, in Montana for \$200 a head. Pablo had first offered his herd for sale to the American government but turned down the paltry bid of \$25 a head.

More than 400 plains bison arrived at Elk Island in two train loads for what was thought to be a temporary stay. They were to be at Elk Island until a fence was erected in Buffalo National Park at Wainwright, Alberta.

In 1909, when the time came to ship them from Elk Island National Park to Wainwright to join the remainder of the Pablo herd, about 50 bison evaded the round up. Park staff likely looked the

other way a few times to ensure that some bison remained behind at Elk Island. Those plains bison became the nucleus of today's park herd.

In 1936 there were 2,479 plains bison grazing in Elk Island. The bison along with elk and deer had begun to overgraze the park vegetation. Wildlife managers wanted to prevent further overgrazing and to stop the practice of supplementing the natural grasses with hay. Bison numbers have been reduced and the herd is now maintained at under 700 animals to prevent starvation, disease, and vegetation damage.

Largely because of the work at Elk Island, the plains bison is no longer considered an endangered species. More than 100,000 plains bison are now found in parks, zoos and private ranches across North America.

Survival – Luck of the Wood Bison



Through a piece of unbelievable luck, the survival of the wood bison subspecies has virtually been assured.

The number of wood bison in their historic range in the forest regions of northwestern Canada is estimated to have been about 170,000. Increased hunting pressure and severe winters were two contributing factors that almost wiped out the entire subspecies. By 1891, there were likely fewer than 300 wood bison in the world. This remnant population was centred in an area that was later set aside as Wood Buffalo National Park in 1922.

A well intentioned but poorly reasoned decision was made that once again

imperilled the survival of the wood bison as a separate subspecies. Between 1925 and 1928, 6,673 plains bison were shipped from Buffalo National Park in Wainwright to Wood Buffalo National Park to give them more rangeland. The Wainwright park was overgrazed and overcrowded.

The introduced plains bison interbred with the resident wood bison and by 1940, pure wood bison were thought to be extinct.

A piece of luck brought a valuable second chance to save the wood bison. In 1957 a herd of about 200 wood bison was discovered by federal wildlife officers in the remote northwest part of Wood Buffalo National Park.

Some of the animals were trapped and used to start two transplanted herds, one allowed to run wild in the newly-created Mackenzie Bison Sanctuary (1963) and the other sent to the fenced sanctuary at Elk Island National Park.

In 1965, 23 animals were shipped to Elk Island National Park where they have been isolated from the plains bison. Conservation officers wanted extra insurance that the wood bison would survive, if the Mackenzie Bison Sanctuary herd got wiped out. Establishing a herd at Elk Island provided that insurance. Elk Island's wood bison are used to restock new herds in areas of their former range.

Several captive breeding herds have been established from Elk Island stock, including those at the Calgary and San Diego zoos.

There are also penned herds in northwestern Alberta, southern Manitoba and in southwestern Yukon, whose offspring will be used for future reintroduction to the wild. Wood bison numbers totalled approximately 2,200 in the spring of 1987.

Managing a Healthy Herd



The goal of bison management in Elk Island is to protect the bison in as natural a state as possible.

The task is to simulate conditions that existed in the area many years ago when the bison roamed the open prairies. Today, the bison are contained in a 194 km² park surrounded by a fence. The fenced herds face no threat from their traditional predators, wolves, grizzly bears and aboriginal man; today no bison from other wandering herds will interbreed with the Elk Island animals; and the herd cannot migrate if the vegetation in the area is stripped.

Steps taken to reach the goal of a healthy herd under these special conditions include limiting the bison population. This is necessary to prevent a dramatic increase of bison that would ultimately result in disease, starvation and damage to the vegetation. When the plains bison herd becomes too large, select animals are gathered in corrals, and made available to wildlife agencies and to the Canadian public. Wood bison, because they are still endangered, are used for breeding purposes in zoos or to form new herds in parts of their historic range, largely in the north.

A major aspect of bison management is monitoring the bison's food supply, the vegetation. After formation of the park in 1906, fires were suppressed allowing the forests to invade the grasslands, the bison's primary food supply. Controlled burns are now conducted to help re-establish the grasslands.

Park wardens also carefully monitor the animals for disease that could seriously affect the entire population. Periodically, the bison are gathered in corrals and tested.

Elk Island National Park has been at the forefront of bison management in North America since the park's formation. Wildlife managers from all over the world visit the park to learn about the special techniques developed here. Elk Island National Park boasts the purest plains and wood bison herds in the world in a setting close to the bison's traditional habitat.

For further information on bison in Elk Island National Park, please talk to a park interpreter, or visit the Astotin Interpretive Centre or the wood bison exhibit.¹

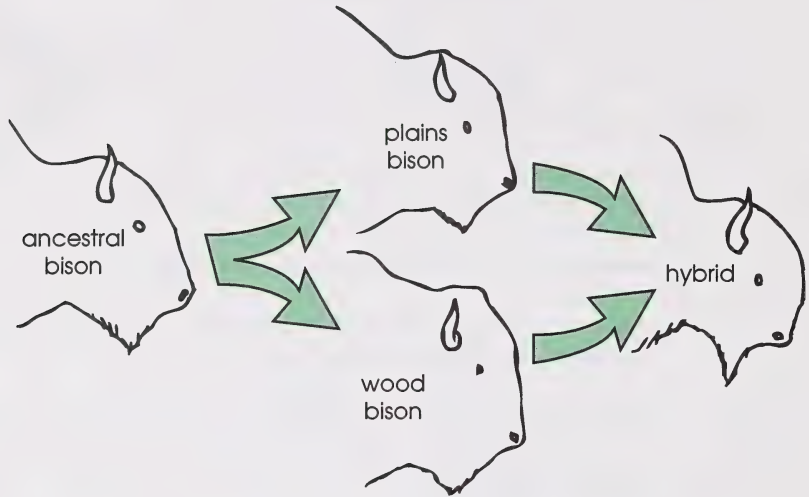


11. a. What event prior to 1940 indicated that the plains bison and wood bison were biologically the same species?
- b. How could the offspring of plains and wood bison be classified?
- c. What was so special about the herd of about 200 wood bison discovered in 1957?
- d. Why are plains bison and wood bison isolated from each other in Elk Island National Park?
- e. Elk Island is a wooded park. How is this habitat made suitable for plains bison?
- f. Protected in the park from natural predators, what could happen to the bison population?
- g. How is the problem in question f solved?
- h. Using the ideas for the mechanisms of speciation that you studied in Activity 1 of this module, explain how the bison slaughter in the 1800s may have resulted in the development of the wood bison as a subspecies.
- i. Identify this selective pressure. This type of selection was discussed in Activity 1.

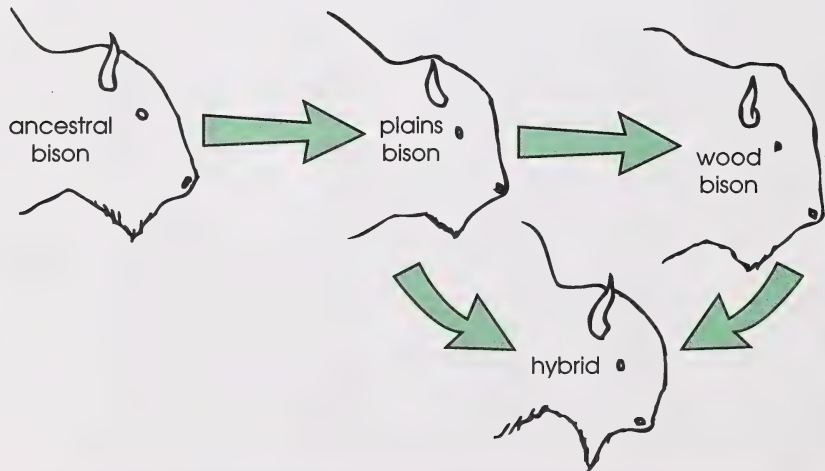
¹ The Minister of the Environment for the brochure, *BISON: You Are in Bison Country – Elk Island National Park*. Reproduced with the permission of Parks Canada, Elk Island National Park.

- j. Examine the following two scenarios of ancestral bison, plains bison, and wood bison lineages. Describe each scenario and propose which scenario illustrates the most likely production of a hybrid.

Scenario 1



Scenario 2



Check your answers by turning to the Appendix, Section 1: Activity 3.

Recall from Module 4 the concept of DNA fingerprinting. Recent DNA fingerprinting studies suggest that there is very little genetic variation between plains and wood bison. One theory as to the difference in physical appearance is that the extreme northern environment affects the development of the individuals. In other words, the phenotypic variations observed between the wood bison and the plains bison are not due to genetic variation, but rather to how the genes are expressed as a result of exposure to the local environment.

Science Skills

- ☒ A. Initiating
- ☐ B. Collecting
- ☐ C. Organizing
- ☐ D. Analysing
- ☐ E. Synthesizing
- ☒ F. Evaluating

12. Design an experiment to test this hypothesis by answering the following questions.

- a. Write a problem statement that clearly identifies the manipulated and responding variables.
- b. Outline a procedure that could be used to verify or falsify the hypothesis.

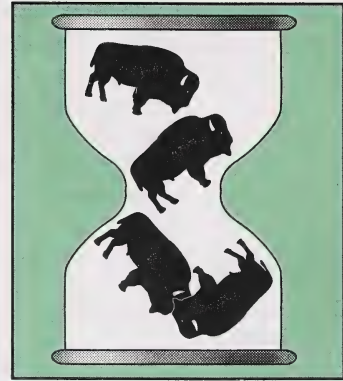
Check your answers by turning to the Appendix, Section 1: Activity 3.



MURRAY CHRISTMAN
ELK ISLAND NATIONAL PARK

Elk Island National Park is an excellent area to view bison and other wildlife, such as elk and moose, in a natural habitat.

Some scientists explain the lack of genetic variation in a species using an hourglass as a model. If for some reason the number of individuals in a population is drastically reduced, as the population reestablishes itself from these small numbers of individuals, variation between individuals is extremely small or nonexistent. The resulting gene pool therefore has little or no variation.



13. Identify some organisms that have experienced very small populations that should be studied to examine their genetic variation in order to support or falsify this hypothesis illustrated by the hourglass model. Explain your thinking.
14. How might genetic variation within a gene pool be increased?
15. Why would this be a very long process?
16. Can the hourglass model be used to explain the controversy regarding the differences between plains and wood bison? Explain.
17. How might geographic isolation between the plains bison and the wood bison have amplified these differences?

Check your answers by turning to the Appendix, Section 1: Activity 3.



COURTESY OF H. ARMBRUSTER
CANADIAN WILDLIFE SERVICE

The biodiversity of the planet is at a tenuous stage. Many organisms are at the brink of extinction. What happens depends on the efforts of humanity. In this section you have learned about how populations of organisms evolve, how these changes can be measured, and the result of evolution (biodiversity). You also learned about human activities that affect wildlife populations. Do not assume that all human activities are bad. Many wildlife populations today owe their existence to human help. The preceding photo shows biologists Harry Armbruster and Charles Mamo releasing a swift fox in southern Alberta.

Follow-up Activities

If you had difficulties understanding the concepts in the activities, it is recommended that you do the Extra Help. If you have a clear understanding of the concepts, it is recommended that you do the Enrichment.

Extra Help

The goal of this section is to have you link the concepts of adaptations and interactions of organisms with genetics of populations. By forming this link, you should be able to analyse the forces of evolution and speciation, use the Hardy-Weinberg principle to interpret genotypic frequency change, and apply these concepts to the management of endangered species. Two short videos that should help you to link these concepts together are available for you to view.



In the first video, you will concentrate on the link between Mendel's work on inheritance, Darwin's theory of natural selection, and the Hardy-Weinberg principle. Watch the ten-minute video entitled *Organic Evolution: Factoring in Mendel*; then answer the following questions by filling in the blanks with the appropriate term.

1. Darwin could have used Mendel's discoveries by learning that units of _____ are not blended together in the offspring, but are _____ within each succeeding generation.
2. Many scientists felt that recessive phenotypes would be _____ by the dominant genes that were found in large populations. This hypothesis was found to be incorrect. The recessive genes will always be _____ in large populations as is stated in the _____ principle.
3. The mathematical binomial theorem was applied to biology by Hardy and Weinberg. The formula is _____.
4. The conditions for the proper functioning of the Hardy-Weinberg equilibrium are that a large, _____ population must have _____ breeding and no internal or _____ forces acting on the population.

The following two questions require you to answer in complete sentences.

5. How was the Punnett square used to formulate the Hardy-Weinberg law?
6. If 80% of the alleles in the gene pool are dominant, what percentage of homozygous dominant and heterozygous and homozygous recessive individuals are found within the population?

Check your answers by turning to the Appendix, Section 1: Extra Help.



In the second video you will want to link meiosis within the gene pool to variation and selection of populations. Watch the ten-minute video entitled *Organic Evolution: Population Picture*; then answer the following questions.

7. Meiosis causes an _____ in variations within a population.
8. A _____ can be thought of as an enormous reservoir of genetic information.
9. Organic evolution is defined as the change in _____ of alleles within a population as described by Hardy and Weinberg.

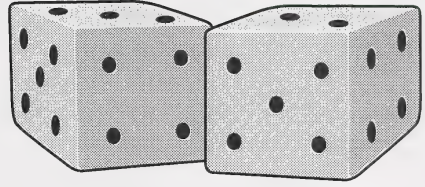
In this video, three types of selection were graphically presented. It is important to be able to interpret these graphs and the forces behind them. The next three questions relate to these graphs.

10. The portion of the population that natural selection tends to favour is the _____ group of individuals. This is referred to as _____ selection.
11. When one extreme is favoured, _____ selection results causing the norm of the population to _____ toward that favoured characteristic.
12. Disruptive selection will result in _____ because the norm of the population is selected against causing an increase in the population at the two _____.
13. A species is defined as a group of organisms that is capable of successfully _____ while occupying the same _____.
14. The gene frequency of a small population that has become isolated may rapidly change due to the _____ probability of random mating. In this case, when random mating is lost, the Hardy-Weinberg principle is not valid. This process of change is called _____.

Check your answers by turning to the Appendix, Section 1: Extra Help.

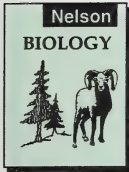
Enrichment

Have you ever played a game using dice? What are your chances of winning? Do you know what the odds are of throwing a seven? This and other questions about probability and the chances of events occurring will be explored in this activity.



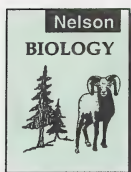
Assume the change in a Hardy-Weinberg calculation for allele q went from 0.30 to 0.35 in a three-year period for a certain population. This, you would further assume, signifies an unstable equilibrium because the frequency of the allele has changed. What about the aspect of chance? Could this change be due to some factor other than evolution of a population? The chances are likely yes. Notice, however, that the **chances** are yes. Whenever a situation arises where chance comes into play, probabilities of an outcome should be determined. A very powerful tool to determine probabilities is the chi-square test. Read pages 563 to 566 of your text to discover how the chi-square test can be utilized; then do the following question to demonstrate your ability to perform statistical analysis.

1. What can and can't probability predict?
2. In tossing a pair of dice, what are the odds of obtaining a seven? (Use Table 24.1 from page 564 of your text.)
3. In your study of genetics, Mendel's work was discussed. What were his two major contributions?
4. Genetics is a vast field of biology with many areas of study where quantitative data is collected. List the genetic concepts that need to utilize probability.
5. What is the importance of using mathematical techniques to assist in analysing data?
6. What does the value of X^2 represent?
7. Write out the chi-square formula and describe what each of the symbols represents.
8. What percentage of probability that an observed deviation was due to chance alone would allow scientists to determine that factors other than chance have affected the results of an experiment?
9. How is this percentage of probability determined using the chi-square tables?
10. For Example 2 of Analysis of Sickle-Cell Anemia Data, determine the problem, hypothesis, and conclusion based on the use of the chi-square test.



Science Skills

- ☒ A. Initiating
- ☒ B. Collecting
- ☒ C. Organizing
- ☒ D. Analysing
- ☐ E. Synthesizing
- ☐ F. Evaluating



11. Design and perform your own experiment by tossing a two-sided object so that you get data that can be analysed using the chi-square test. Your results will be unique to the number of times you toss the object and the number of times each side lands up. The actual values are not as important as the process of using the chi-square formula and table. Be sure to include all parts of an experimental design when setting up your experiment.
12. Demonstrate your ability to use the chi-square test by answering question 6 in Applying the Concepts on page 575 of your text.



Check your answers by turning to the Appendix, Section 1: Enrichment.

Contact Elk Island National Park for information on bison and opportunities to participate in interpretive programs.

Elk Island National Park
Phone: 922-5790 or 992-6380

Conclusion

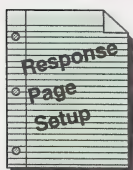
In this section you have learned that some species are threatened by fragmentation of habitat and that ecological reserves are one way to prevent the loss of a species' uniqueness. You have also learned that a species' uniqueness is found within the gene pool of the population. Through the use of the Hardy-Weinberg principle, you have discovered how to use gene frequencies to determine whether a species is undergoing changes to its gene pool. You also had an opportunity in the Enrichment activity to learn about the chi-square test which determines if variation is likely due to chance or some other external factor.

55

Section 1 Assignment: Population Genetics

Review the Evaluation information found in the introductory pages of this module.

It is important to number and clearly identify each page with the following information at the top:



Biology 30 – Module 6 Section 1 Assignment Page # Name and ID#

Be sure to write legibly. Leave a wide left margin and number all of your pages.

Carefully read each of the following multiple choice questions and decide which of the choices **best** completes the statement or answers the question. Each question is worth 1 mark.

1. In a random breeding population of a small mammal, the gene for coat colour has two alleles: *G*, which is dominant producing a grey coat, and *g* which is recessive producing a white coat. The white individuals are selected against by hawk predation such that each individual has a 10% probability of surviving to a reproductive age, while the grey animals have a 75% probability. Which of the following statements will best describe the population for these alleles after 100 generations of continued random breeding?
 - A. The *G* allele will now be the only allele present in the population.
 - B. The *g* allele will now be the only allele present in the population.
 - C. Both alleles will be present in equal numbers.
 - D. The *G* allele will be the allele with the highest frequency and the *g* allele will still be present.
2. The production of new genes or changes in allelic forms is the result of
 - A. gene flow
 - B. genetic drift
 - C. mutation
 - D. adaptation
3. The major evolutionary force that causes changes in gene frequencies is
 - A. Hardy-Weinberg principle
 - B. natural selection
 - C. directional selection
 - D. bottleneck effect
4. A type of natural selection in which the phenotypic extremes are favoured over the average phenotype is
 - A. stabilizing selection
 - B. coevolution
 - C. directional selection
 - D. disruptive selection
5. Hardy-Weinberg equilibrium
 - A. rarely occurs in nature because most populations are evolving
 - B. never occurs in nature because it is a principle to be applied to hypothetical situations
 - C. occurs only in strictly controlled laboratory situations
 - D. will occur if the population is small and breeds randomly

6. Speciation can result from
 - A. reproductive isolation
 - B. geographic isolation
 - C. disruptive selection
 - D. all of the above
7. When individuals from a population migrate to an area of another population of the same species and begin interbreeding, this situation is most likely called
 - A. genetic drift
 - B. gene flow
 - C. speciation
 - D. directional selection
8. What is the difference between a population and a gene pool?
 - A. There is no difference.
 - B. The population remains constant but the gene pool changes.
 - C. A population is comprised of the same species and a gene pool is comprised of all their genes.
 - D. Populations are less important to evolution than are gene pools.
9. The equation $p^2 + 2pq + q^2 = 1$ describes
 - A. the process of evolution
 - B. the size of a population
 - C. the natural selection law
 - D. the makeup of a gene pool

Use the following diagram to answer the next two questions.

	0.6 C	0.4 c
0.6 C		
0.4 c		

10. The homozygous dominant individuals constitute what proportion of the population?
 - A. 0.6%
 - B. 52%
 - C. 36%
 - D. 24%

11. What proportion of the gametes in this population contain gene *c*?
 - A. 0.16%
 - B. 24%
 - C. 40%
 - D. 48%
12. In a population in which 1% has sickle-cell anemia, what percentage of the population are carriers for the trait?
 - A. 81%
 - B. 1%
 - C. 18%
 - D. 99%
13. A scientist determines that 9% of a human population is albino resulting from recessive genes for skin pigmentation. What is the frequency of the recessive allele in this population?
 - A. 1.0
 - B. 0.1
 - C. 0.03
 - D. 0.3
14. Which type of natural selection increases the frequency of one extreme phenotype?
 - A. directional
 - B. stabilizing
 - C. disruptive
 - D. none of the above
15. Once speciation has occurred
 - A. gene flow ceases
 - B. reproductive isolation exists
 - C. two species exist
 - D. all of the above
16. Evolution by natural selection would be least in a population
 - A. that is on the verge of extinction
 - B. with no predators or competitors
 - C. with large phenotypic variations
 - D. that has a stable number of members

17. Two populations of field mice become separated by a new highway so that gene flow is now impossible. After ten years a researcher detects that evolutionary change has occurred in the populations. Mice found on the east side of the highway have a higher percentage of individuals with longer and darker whiskers than the population found on the west side of the highway. The two habitats are identical. What is the most probable reason for the difference?
- A. Natural selection has occurred in each group.
 - B. Nonrandom mating has occurred.
 - C. Mutations have occurred in each group.
 - D. Genetic drift has occurred in each group.
18. The most effective means of conservation is to
- A. remove predators
 - B. preserve habitats
 - C. vaccinate against disease
 - D. census the species during breeding season
19. In a large community of humans it is found that only 2% of the people do not have freckles (freckles result from a dominant gene). Determine the percentage of people who are heterozygous for the trait. Show your work. **(2 marks)**
20. Place the following events in the proper order that will cause and then ensure speciation.
- a. geographic isolation occurs
 - b. reproductive isolation occurs
 - c. speciation occurs
 - d. disruptive selection occurs **(2 marks)**
21. The Hardy-Weinberg principle is founded upon five main conditions. In a paragraph explain why these conditions are difficult to observe in natural populations. **(5 marks)**
22. Sixty-four percent of a population is able to taste a chemical called PTC. Tasters are either homozygous dominant or heterozygous for the trait. For the calculations that follow, marks will be awarded for all relevant formulas, calculations, and statements.
- a. Calculate the percentage of the population that
 - i. is unable to taste PTC **(1 mark)**
 - ii. is heterozygous for the trait **(3 marks)**
 - iii. carries the recessive allele **(2 marks)**
 - b. The next generation of the population maintains the same frequencies for the alleles controlling the ability to taste PTC. Explain what this proves. **(2 marks)**

23. *Passer domesticus* is the common house sparrow of North America. There are three different genotypes – *DD*, *DE*, and *EE* – that are caused by two alleles at the same locus. The following table provides data on the numbers of these genotypes on a population from Alberta studied from six different years.

Year	Number Counted	<i>DD</i>	<i>DE</i>	<i>EE</i>
1964	472	12	80	380
1969	1352	13	165	1174
1972	1623	5	140	1478
1977	1467	1	72	1394
1984	1137	3	48	1086
1989	955	2	21	932

- Calculate the frequency of the *E* allele (*q*) in all six sampling years to two decimal places. **(3 marks)**
 - Draw a graph illustrating the frequency of the *E* allele over the fifteen years of the study. **(4 marks)**
 - Suggest what the numbers indicate about changes that may be occurring in the population and predict the relative frequencies of *D* and *E* alleles in the future. **(2 marks)**
24. In the 1940s chemical pesticides including DDT were used in Canada to control insect pests that were harming crops. More than 400 pest species have evolved some type of resistance to the pesticides.
- Explain how the use of DDT and other insecticides may lead to speciation in insects. **(3 marks)**

Use this information to answer question 24. b.

Strains of streptococcal bacteria have shown resistance to the antibiotic penicillin. This is occurring in people who, when prescribed the antibiotic, take it only long enough to feel better. They do not take it until the end of the prescription which would have killed all of the bacteria causing the infection.

- Describe how natural selection has occurred as a result of the bacteria developing a resistance to the antibiotic. **(4 marks)**
 - Explain how natural selection of a species could be reduced by selective pressure. Give a simple example. **(2 marks)**
25. Aldo Leopold, sometimes called the father of ecology, once stated “The important part of intelligent tinkering is to keep all of the parts.” Use this statement to explain the importance of maintaining biodiversity. **(2 marks)**

Interactions and Relationships



A red-tailed hawk sits on a power pole on a hot summer afternoon. In the field below, a farmer is baling hay. The hawk watches intently and suddenly lifts from its perch. Gliding toward the earth with claws outstretched, it strikes a mouse. Lifting off with powerful wingbeats, the hawk goes to a nearby tree to eat the mouse. Energy moves through the food chain.

If you watched this life and death drama, who would you cheer for, the predator or the prey? Few people consider the fact that the predator may soon starve to death if it does not kill successfully. In the struggle to survive, predation is just one example of the wide variety of complex relationships that occur in the natural world. This section will take you on a journey through these interactions. As you study these relationships, keep in mind that species and populations, alone or interacting, represent gene pools.

The activities in this section will guide you through the world of predation and other relationships. You will undertake a close examination of predator-prey relationships, and analyse predator-prey dynamics. You will also learn about the different types of relationships that many organisms exhibit and discover some of the interesting ways to avoid becoming someone else's dinner.

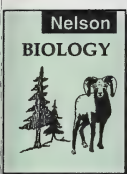
ACTIVITY

1 Predation

"Master, I marvel how the fishes live in the sea."

"Why, as men do a-land: the great ones eat up the little ones."

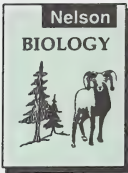
—Shakespeare, *Pericles, Prince of Tyre*



Killing to survive is likely not a part of your normal daily routine. For most people the acquisition of food is a trip to the market and an outlay of some of their hard-earned money. Quite a few people in today's society fail to equate the meat in a wrapped package with the muscles of a formerly living animal. In the real world predators must kill and eat regularly or they will not survive. Biology 20 introduced you to the idea that matter and energy in an ecosystem move through populations of organisms. This was clearly shown by a food chain. View Figure 2.6 on page 48 in your text for a typical example.

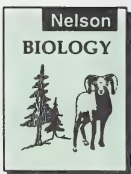
Predation upon other organisms must take place if energy and matter is to be passed on in the ecosystem. In this activity you will be examining the basic principles of predation and how organisms have co-evolved in the predator-prey relationship.





To begin your discovery of predation, read pages 595 to 596 of your text. You may also wish to review pages 47 to 50, 52 to 53, and 56 to 57 to refresh your memory about the concepts studied in Biology 20. When you are ready, answer the following questions.

1. Describe what a predator gains when it consumes another organism.
2. Outline the movement of energy and matter in an ecosystem. Differentiate between flow and cycle.
3. In terms of energy, why should the number of predators be exceeded by the number of prey?



How does the number of prey compare to the number of predators? The population graph in Figure 25.19 on page 590 of your text shows you an interesting correlation between the population of lynx and snowshoe hare. Examine the graph closely and then answer the questions that follow.

4. Describe the relationship between the lynx population and the hare population.
5. Does the lynx exert any pressure on the hare population? Explain.
6. Provide an explanation as to the cyclical nature of the population variations.
7. There is a lag phase in the variations in the lynx populations when compared to the hare populations. Why would this be expected to occur?

Science Skills

☐ A. Initiating

☐ B. Collecting

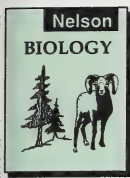
☐ C. Organizing

☒ D. Analysing

☐ E. Synthesizing

☐ F. Evaluating

Check your answers by turning to the Appendix, Section 2: Activity 1.



The animals that are preyed upon often do not have significant means of defence. Very often the best defence is to not be found. That is the principle behind camouflage. The snowshoe hare shown in Figure 25.24 on page 595 in your text is camouflaged in winter colours. In summer it will turn to brown.

8. What would happen if this animal was not camouflaged?
9. What is the main principle behind the concept of camouflage?

Newborn deer have almost no body scent. They also have a behaviour of lying low and motionless for long periods of time.

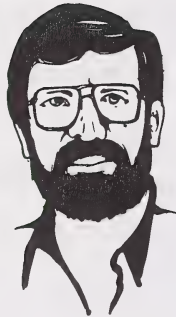


10. Describe how these behaviours increase the survival chances of the fawn.

Newborn caribou can travel with their mothers within minutes of being born.

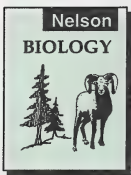
11. How does this strategy protect against predation?
12. What relationship exists between these physical traits and behaviours that reduces predation and the allelic frequency for them in the gene pool of these organisms?

Check your answers by turning to the Appendix, Section 2: Activity 1.



Survival is good for your genes.

Not being eaten is a selective process. Those animals that survive due to their hiding or escaping capabilities will pass those genes on to their offspring. Now you will discover why certain organisms put on a colourful display rather than hide.



Being stung by a bee or wasp is quite a painful experience. To some people it is even deadly. Once you have been stung you learn to avoid bees or wasps in the future. Examine the photos on page 596 of your text. Can you tell which species will sting you? Only the upper left photo is a true wasp.

13. What is the purpose behind the dramatic colouration of bees and wasps and other insects?
14. What advantage would a harmless fly have in adopting a colouration pattern similar to that of a bee or wasp?

What you have just observed is a classic example of mimicry. This often occurs when a harmless species takes on the appearance of a harmful one.

Monarch butterflies have evolved a complex defence mechanism using colouration and poison. The monarch butterfly lays its eggs on the leaves of the milkweed plant. The milkweed produces a toxic cardiac glycoside that stimulates the nervous system to induce vomiting in animals that forage on it. (This chemical in minute amounts is also used to treat certain heart conditions in humans.) When the larvae hatch they consume the leaves of the milkweed and concentrate the toxin in their bodies. After pupation, the adult monarch butterfly now has this toxic chemical stored in its body. Any predator that eats it will become ill and vomit violently.



15. The set of events described on the previous page have drastic consequences for the eaten butterfly. What is the significance to the entire population of monarch butterflies?

A butterfly known as the viceroy has evolved colouration similar to the monarch. It does not have the same behaviour though of laying its eggs on milkweed plants or concentrating cardiac glycosides.



16. Explain why the monarch butterfly required two stages (physiological and behavioural) while the viceroy required only one (physiological) to evolve a defence mechanism.

Check your answers by turning to the Appendix, Section 2: Activity 1.

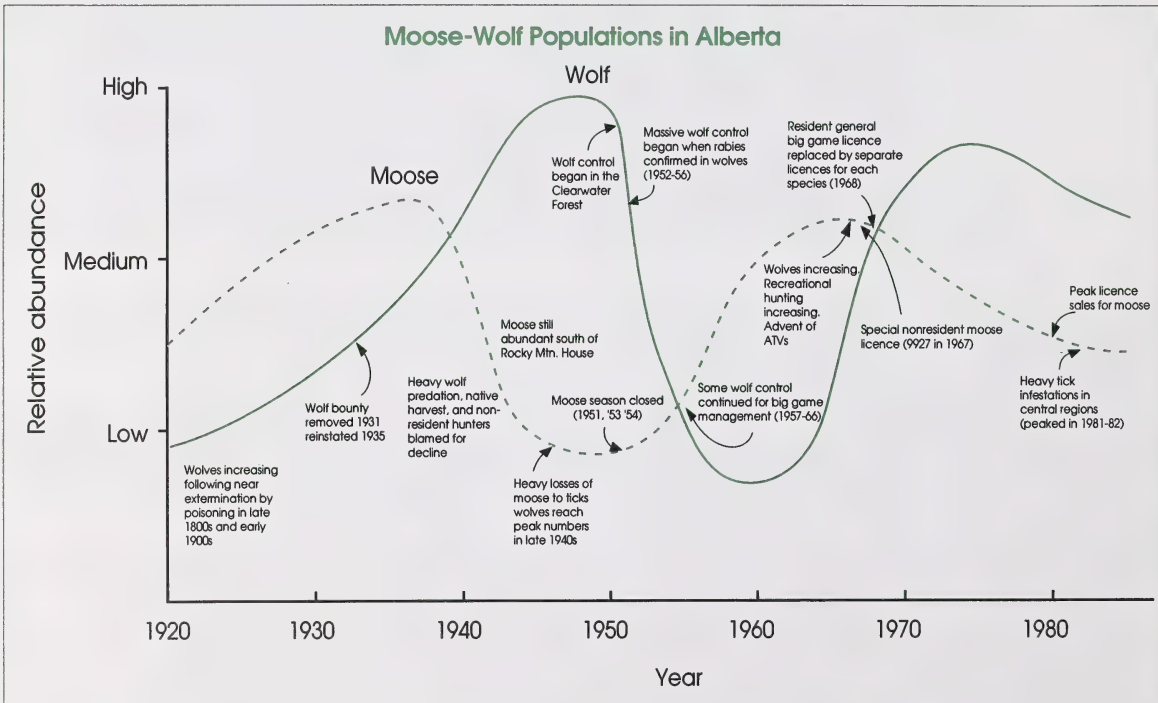
Predators must kill to survive. Why doesn't this eliminate all the prey? Animals that are preyed upon have evolved special body structures and strategies to avoid predation. Prey must escape to survive. The fact that predators and prey have survived for thousands of years is evidence that both have responsive gene pools. In the next activity you will explore how the populations of predators and their prey change as a result of the interaction between them.

ACTIVITY

2

Investigating Predation

Predators come in all shapes and sizes. From the tiny shrew to the mighty grizzly bear, each predator has an effect on prey that it feeds upon. One example that has attracted a great deal of attention has been that of the wolf and the moose. Examine the following graph which shows the variations in wolf and moose populations in Alberta; then answer the questions that follow.



¹ Alberta Fish and Wildlife Services for the graph taken from *Management Plan for Wolves in Alberta*, Issue No. 4, December 1991, p. 10. Reprinted with permission of Alberta Fish and Wildlife Services.

1. Do the variations follow the expected pattern? Explain.
2. Describe the pattern of variations illustrated by the graph.
3. What is the approximate cycle frequency for both the moose and wolf populations?
4. The wolf population follows that of the moose but appears to be out of phase. Explain why this is to be expected.

Wolf and moose populations in Alberta are managed to control their populations. At times, certain human activities have either increased or decreased the population of these organisms.

5. Identify a change in one of these populations that is not the result of the companion species but rather due to some sort of human intervention.

Check your answers by turning to the Appendix, Section 2: Activity 2.

The moose is not the only prey of the wolf. Another animal preyed upon by the wolf is the “grey ghost of the forest,” the caribou. To lose the caribou would be a tragedy. What has happened to cause these furtive animals of the forest to begin to disappear? Is it hunting, habitat destruction, predation, disease, or a combination of these and other factors?



COURTESY OF D. THOMAS
CANADIAN WILDLIFE SERVICE

Science Skills

- ☐ A. Initiating
- ☐ B. Collecting
- ☒ C. Organizing
- ☒ D. Analysing
- ☐ E. Synthesizing
- ☒ F. Evaluating

Janet Edmonds and Kirby Smith are wildlife biologists for Alberta Fish and Wildlife. Since 1980 they have been involved with studying the caribou populations in west central Alberta. In Activity 3 of Section 1 you examined a map that delineated the winter ranges of the caribou. These are mature pine or mixed pine and black spruce forests that contain large amounts of lichen, the preferred winter food for caribou. Lichens are very slow growing so they are found in large amounts only in mature, old-growth forests. The logging of these forests has decreased the available habitat for caribou. The caribou population has been declining since the 1970s. The decrease in the population of caribou is greater than what was to be expected for the amount of logging that has taken place. The following excerpt from a journal on caribou will provide you with further information to solve the disappearing caribou mystery.

Forest-Dwelling Caribou

A low prey-predator equilibrium will occur when the number of prey killed by predators increases rapidly as a function of prey density relative to the annual increment curve. That situation will occur when the prey lack an effective anti-predator strategy or when predators are sustained by alternate prey species even when the prey species of interest is at low densities. Caribou populations below treeline in North America are more vulnerable to wolf predation than Arctic caribou because wolf populations are maintained by a variety of prey species and the caribou do not have long-distance migrations to space themselves away from wolves. Also, other predators such as bears (*Ursus* spp.) are more abundant than in Arctic areas and remove an additional component of the annual increment. Wolf populations are sustained by a variety of prey species including caribou, moose, mountain sheep (*Ovis* spp.), elk (*Cervus elaphus*) and deer

(*Odocoileus* spp.). Therefore, wolf numbers can remain high even if predation has drastically reduced one of the prey species. Increases in the abundance of one of the prey species may support increased wolf numbers and thereby have deleterious effects on one or more of the other prey species. Caribou are extremely vulnerable to wolf predation compared to most other ungulate species. They are unable to fight off predators the way moose can, they do not use escape terrain like mountain sheep and mountain goats (*Oreamnos americana*), and they have a low reproductive rate compared to most other ungulates such as deer so they cannot sustain high levels of predation. Therefore, caribou populations are usually the most vulnerable species in multiple prey-predator systems. Wolf predation can eliminate caribou from areas where the wolf population is sustained by other prey species because there is no negative feedback on the number of wolves as caribou decline.¹

6. Explain how limited logging in an area may indirectly contribute to the decline in a caribou population.
7. Propose a solution to the problem, using paragraph format. Will this be a permanent solution? Be sure to defend your proposal.
8. Is your solution controversial? Explain.

Science Skills

- ☐ A. Initiating
- ☐ B. Collecting
- ☐ C. Organizing
- ☒ D. Analysing
- ☒ E. Synthesizing
- ☒ F. Evaluating

Check your answers by turning to the Appendix, Section 2: Activity 2.

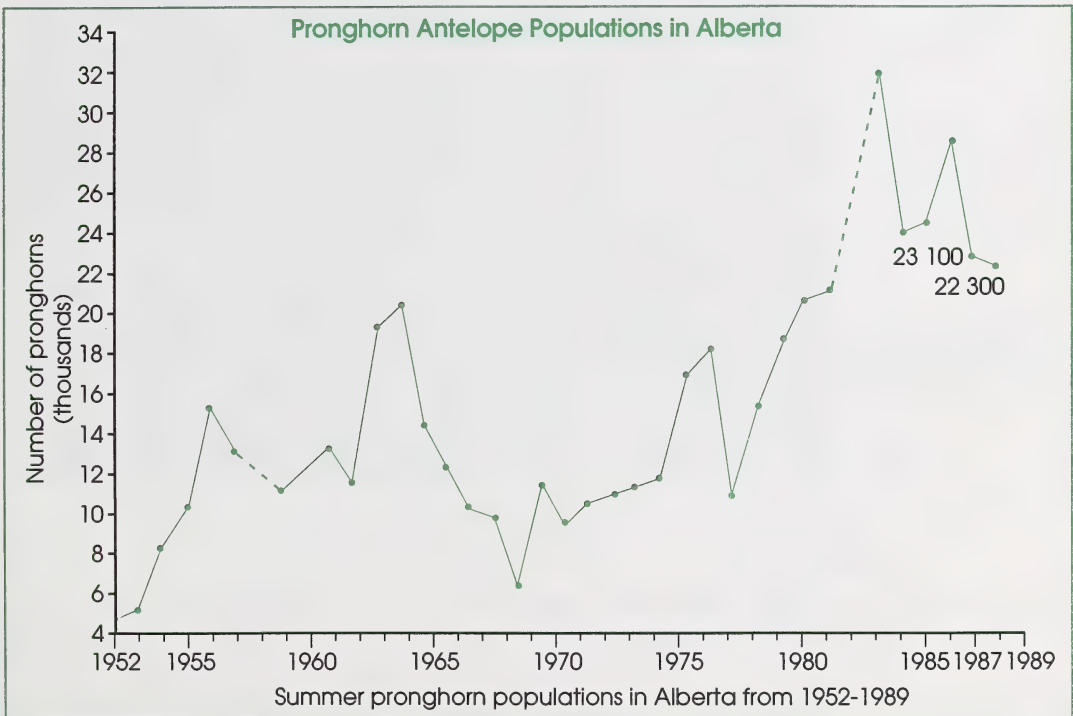
¹ *Rangifer*, for the article excerpt "Forest-Dwelling Caribou," by Dale Seip, Special Issue No. 7, 1991, pp. 49-50. Reprinted with permission of the *Rangifer*.

Alberta's wildlife biologists are working on saving the caribou. Decisions will soon be made. If you would like more information on wildlife management in Alberta, contact your local Fish and Wildlife office.

Pronghorn antelope are plains animals that must coexist with humans. The graph that follows shows the population changes for the pronghorn antelope. Predation by coyotes and bobcats may account for a 50% loss of the fawns in any one season. Predation by humans through a controlled hunting season removes approximately 20% of the adult population.



Use the following graph to answer questions 9 to 11.



This graph again illustrates a cyclical change in the pronghorn population.

¹ Alberta Fish and Wildlife Services for the graph taken from *Management Plan for Pronghorn Antelope in Alberta*, Issue No. 3, November 1990, p. 14. Reprinted with permission of Alberta Fish and Wildlife Services.

9. What is the frequency of this organism's population changes?

Science Skills

- ☐ A. Initiating
- ☒ B. Collecting
- ☐ C. Organizing
- ☒ D. Analysing
- ☒ E. Synthesizing
- ☐ F. Evaluating

10. Which organisms that you studied show a similar cycle?

11. With the absence of a major predator, propose an hypothesis for this cyclical behaviour.

Check your answers by turning to the Appendix, Section 2: Activity 2.

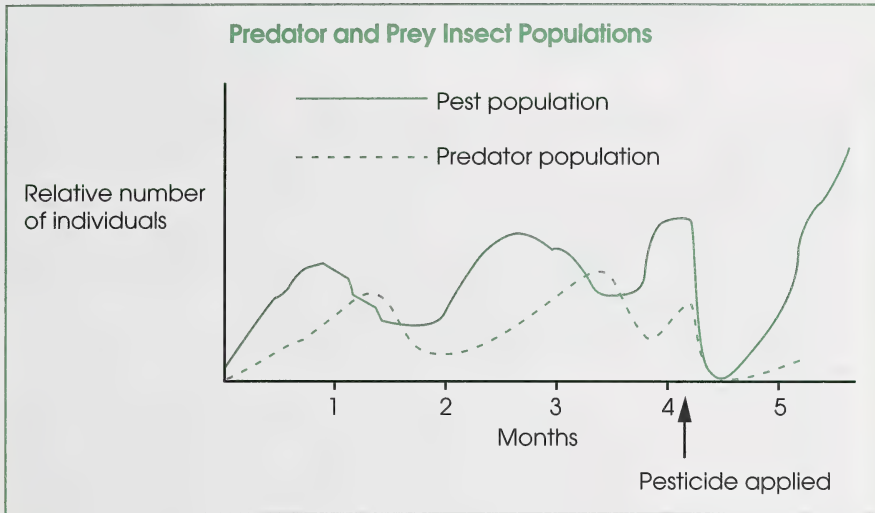
biological control – a method of controlling an organism's population by using a predator or parasite

Are you bugged by bugs? Are there aphids on your apples? Do you rush out with insecticidal sprays or are there other solutions? Have you heard of **biological control**? Predators come in all shapes and sizes. Some are useful to humans as biological controls.



One method of biologically controlling an insect pest is to introduce a large number of predatory insects. In your garden or greenhouse it can be as simple as adding a large number of ladybird beetles. These carnivorous insects will rapidly decimate certain pest populations. The only problem is keeping them in your yard. Greenhouses often have a problem with white flies. Rather than spraying, some horticulturists order a parasitic wasp – yes, you can really order these – that will lay eggs on the immature flies. When the eggs hatch, the larvae eat the flies, thus destroying them. There is a tremendous amount of research going into means of biological control; this is definitely a growth industry.

Examine the following graph; then answer the question that follows.



12. Using your knowledge of predator-prey relationships, explain why the pest population increased dramatically after the pesticide was applied.

Predators as well as prey require habitat to survive. They need special places for cover, reproducing, and feeding. Very often agricultural crops do not provide for these needs.

13. Removing the native plants surrounding an agricultural crop can often increase an insect pest problem. Explain how this would occur.

Check your answers by turning to the Appendix, Section 2: Activity 2.

Predator-prey relationships obviously existed long before humans came along. However, human activities can have a strong effect on one type of organism followed by a corresponding reaction by the other organism. Because of the interrelationships in food chains and food webs, changes usually affect many species.

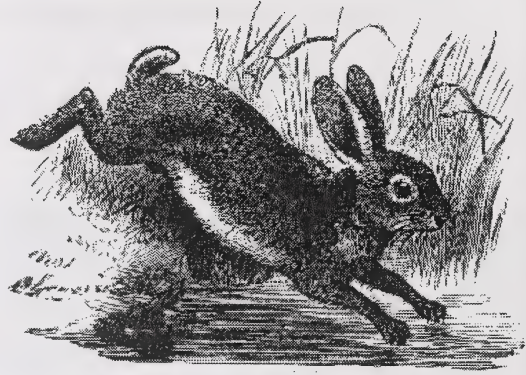
The video *The Spruce and the Hare* will help you review the main ideas of predation. The questions follow the video, so feel free to stop the program and record your answers during the program.

14. How often do the hare populations peak?
15. Use two reasons to explain why the hare population cycles.
16. How do the regrowing forests protect the hares from predation?

Science Skills

- ☐ A. Initiating
- ☐ B. Collecting
- ☐ C. Organizing
- ☒ D. Analysing
- ☒ E. Synthesizing
- ☐ F. Evaluating

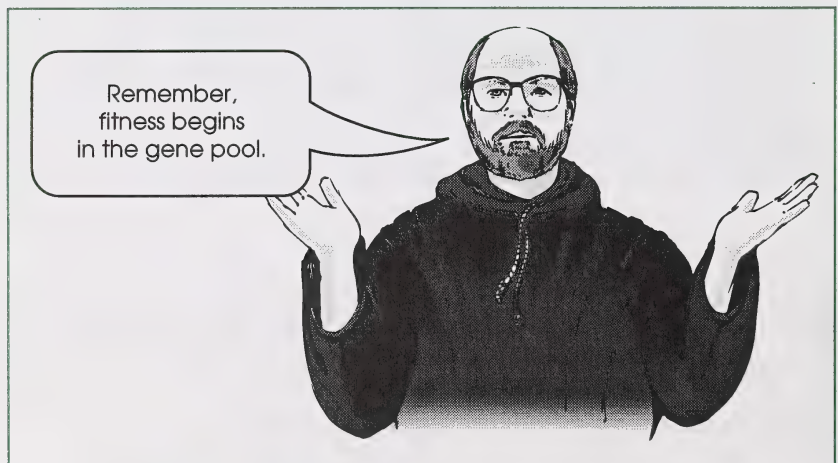
17. What is the advantage of the hares being white in winter, brown in summer, and mottled in the spring and fall?
18. Why would artificially reducing the hare population to very low numbers not be an acceptable solution?



19. Why do predator populations increase as the hare population increases?
20. Identify the reason for the predator populations crashing after the hares suddenly die off.
21. In a short paragraph discuss the statement "The hare is a keystone species for many predators."

Check your answers by turning to the Appendix, Section 2: Activity 2.

The relationships that exist between predators and prey demonstrates the tenuous nature of life. The constant struggle for survival ensures that only the fittest individuals survive.



ACTIVITY

3 Living Together



DUCKS UNLIMITED

One of the first signs that spring has finally arrived is the melodic sound of a red-winged blackbird calling out a territorial song. What is the purpose of this noisy male announcing his presence to all those who can hear him? How do other birds respond to his calling?

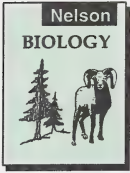
In this activity you will study two forms of interaction. First you will discover how organisms struggle for their basic needs through competition and how the behaviours of these organisms attempt to ensure their survival. In the second part of this activity you will explore the amazing world of symbiotic relationships that organisms have co-evolved to live together.

Competition

The first type of interaction you will explore is competition. To learn about this, read pages 594 and 595 in your text on intraspecific and interspecific competition; then answer the following questions.

1. Explain Gause's principle.





2. In the top two graphs of Figure 25.23 on page 595 of your text, the population density remains high. Explain why the populations of both changed and the purple line falls to zero in the bottom graph.
3. Give three reasons why one species of paramecium would have died out due to interspecific competition.
4. State the kind of competition occurring within a population.
5. How is intraspecific competition one of the forces that drives natural selection?

Check your answers by turning to the Appendix, Section 2: Activity 3.



Human activities such as logging sometimes drastically alter the habitat, particularly by changing or removing vegetation. You must not forget that humans are just like any other species interacting with the community. You too compete with other species for the resources of the Earth. Some human actions are careless, cause a great deal of destruction, and threaten to drive numerous species to extinction. Are these actions simply a natural form of competition? Should checks be put upon actions so that other species will not suffer the fate of the passenger pigeon that became extinct in 1914?

These are difficult questions and the answers are not easy because so much of the habitat destruction is due to a drive of humans to survive and become more advanced. The following is a list of some of the pressures put upon other species by human activities.

- destruction of natural habitat for food production which harms space needed for breeding sites

- killing of animals for specific body parts that are used for decorative or medicinal purposes such as elephant ivory or bear gall bladders
- use of poison to get rid of plant or animal pests causing the accumulation of the poison in top carnivores
- introduction of exotic species into a new habitat for the purpose of sport, such as the rabbit being introduced into Australia causing an increase in competition for food among other native species
- war, such as in Kuwait where the oil fields were destroyed, resulting in the destruction of wide ranges of natural habitat

These are some situations that require careful thought as to their necessity.

6. Make a point/counterpoint chart regarding the destruction of forest by humans for the purpose of producing more agricultural land for food production.

Check your answers by turning to the Appendix, Section 2: Activity 3.

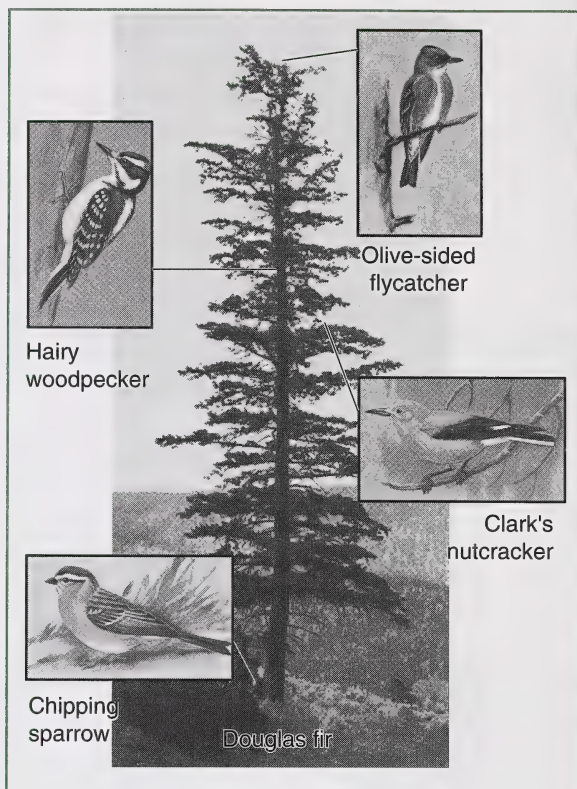
Interspecific competition within the animal and plant world can seem less harsh than the awesome competitive drive of humans in the biosphere. The end result, however, can be just as devastating.

In most cases the competition between species will cause the species to divide the available resources. Recall in Biology 20 where the niches of organisms were discussed. The hawk and the owl occupy nearly the same niche. The difference is that the hawk hunts during the day and the owl hunts at night. These two competing species were able to partition the resources during a day to reduce the stress of competition.



resource partitioning – the use of spatial or temporal behaviours to separate similar niches occupied by similar species

A detailed example of **resource partitioning** as a result of interspecific competition is shown in the diagram on the right. You can see that four birds all forage on the Douglas fir but in different locations and on a slightly different food source. The niches of the birds are slightly different, which causes a decrease in the stress on the species and a better chance for survival.



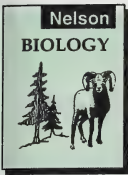
Another example is that grey squirrels, mice, white-tailed deer, and blue jays in eastern Canada all compete for acorns as a food source. Normally they are able to partition the resources when the food supply is plentiful.

7. What survival strategies might the mice employ if acorns become scarce during a poor crop year?

Check your answers by turning to the Appendix, Section 2: Activity 3.

Symbiosis

Species that live together do not always compete. You did not always have to compete for survival when you were growing up, although it could have been an influence. You will now explore symbiosis in which species can be cooperative and exploitive.



To begin this topic, read pages 596 to 598 in your text on symbiotic relationships and answer the following questions.

8. Do Review questions 24 and 25 on page 598.
9. In the following relationships, state which type of relationship(s) is (are) being described and explain why you came to that conclusion.
 - a. Plankton are the primary food source of baleen whales and penguins.
 - b. Acute vision and hearing make ostriches reliable guards for grazing animals such as the zebra.
 - c. A clown fish quickly hides in the poisonous tentacles of the sea anemone when a larger fish begins the chase. The clown fish has a protective membrane preventing the poison from affecting it.
 - d. Two coyotes quickly run toward the bleating sounds of an injured rabbit.



- e. A particular species of ant cleans the leaves of the acacia tree, while living within the tree's hollowed-out, non-functioning branches. The ants' colony provides a home for scale bugs which feed by sucking juices from the acacia tree. The ants' food supply is the sweet liquid secreted by the scale bug, not the scale bug itself.

Check your answers by turning to the Appendix, Section 2: Activity 3.

allelopathy – a chemical method that plants use to compete with other plants

So far you have explored competition among animals. But did you know that plant species compete too? An example of this is when one plant species produces chemicals that prevent the growth of other plants. The release of these growth-inhibiting chemicals into the soil is known as **allelopathy**. The following laboratory can give you first-hand experience in working with competing species. This lab requires careful control of sterile conditions and technique. The lab has been designed for student use by Prairie Biological Inc., Edmonton, Alberta. They can be contacted for more information about this laboratory and about other research in this area.

Prairie Biological Inc.
4290-91 A Street (Block C)
Edmonton, Alberta T6E 5V2
Phone: 450-3957

Investigation: Allelopathy

Objective

exudate – any chemical released by an organism

The objective is to investigate the use of **exudates** on the germination and growth of seeds and work toward the development of a scientific theory for allelopathy.

Background Information

In 1633 an English scientist, Culpepper, noted that rue and basil never grew near one another. He also noted that when cabbage and grape vines were planted near one another, only one would survive. In another discovery by two other scientists, it was found that certain plants would not grow under black walnut trees. They found that water that dripped off the trees' leaves contained a particular chemical or exudate that inhibited the growth of some other plants. The term used to describe this effect was *allelopathy*. What separates allelopathy from general competition is the involvement of a chemical or exudate that is added to the environment. The exudate, like all chemicals, is synthesized within a cell and is controlled by the DNA of a cell. Competition according to a traditional definition involves the removal or reduction of an essential environmental element by one species. A species of plant that grows faster than a competing species will develop a more complex root system, which ensures a greater allocation of minerals, water, and soil nutrients. The shade provided by the leaves of the rapidly growing plant will limit photosynthesis, thereby slowing the growth of the competing plant even more. The winner of the competition will be decided by the rate at which plants grow. Allelopathy, or the production of chemical exudates, introduces another group of variables into the scheme of competition. The slower growing plant might derive an advantage by producing an inhibitory chemical and slowing the growth rate of its competitors.

Note: Read through the entire laboratory before attempting the procedure.

Materials

- 9 petri dishes
- wax pencil*
- magnifying glass
- 250 mL alcohol (methanol from pharmacy)*
- 36 sterile filter papers, sized to fit in the lid of the petri dish
- tweezers
- 3 10-mL graduated cylinders
- 1 L of cooled boiled water*
- 100 seeds each of canola, alfalfa, cucumber (or radish)
- exudates A and B

* supplied by student

Procedure

- Using a wax pencil, label the top half of each of the nine petri dishes according to the legend that follows. (Do not open the petri dishes, just label the top.)

Seed Type	Exudate A	Exudate B	Control
Canola	<i>Can A</i>	<i>Can B</i>	<i>Can C</i>
Alfalfa	<i>Alf A</i>	<i>Alf B</i>	<i>Alf C</i>
Cucumber	<i>Cuc A</i>	<i>Cuc B</i>	<i>Cuc C</i>

Can = canola

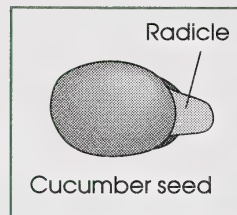
Cuc = cucumber

Alf = alfalfa

(or Rad = radish)

- Dip the tweezers into the alcohol briefly to sterilize them. Gently shake off the excess alcohol before handling the seeds. To sterilize the graduated cylinders, rinse them with alcohol and gently shake out the excess.
- Using sterilized tweezers, place four filter papers into each of the petri dishes. Carefully cut the filter papers to fit if necessary.
- Take a sterile graduated cylinder and transfer 4 mL of previously boiled water into each of the three control petri dishes to moisten the filter paper. Replace the appropriately labelled lid.
- Take another graduated cylinder and transfer 4 mL of Exudate A to each of the three marked petri dishes. Replace the appropriately labelled lids. Repeat this procedure for the three Exudate B petri dishes, using the last graduated cylinder and Exudate B. Do not mix up the graduated cylinders.
- Using the tweezers, count out thirty of each type of seed. Place the seeds directly onto the moistened filter paper of each appropriately labelled petri dish. Attempt to distribute the seeds in a uniform pattern on the filter paper to allow for an easier view in the future.

- Place the petri dishes in a warm area, preferably 20°C, where they will not be disturbed for the next three days.
- After 24 h, use the magnifying glass to observe the seeds. Count the number that have a radicle exposed. These seeds are germinating. Repeat this procedure after 48 h and 72 h and record your results. In your results also include the percent that have germinated.



Observations

10. Create an appropriate chart to record the type of seed and group, the number and percent that have germinated, as well as the length of the root.

Analysis and Interpretation

Science Skills

- ☐ A. Initiating
- ☒ B. Collecting
- ☒ C. Organizing
- ☒ D. Analysing
- ☒ E. Synthesizing
- ☐ F. Evaluating

11.
 - a. Write a problem for this investigation.
 - b. Formulate an hypothesis for the effect of the exudates on seed germination.
 - c. Why was sterile technique used for the set-up of the investigation?
 - d. Explain the purpose of the control group for this investigation.
 - e. Why were thirty seeds used for each test rather than one or two?
 - f. Which exudate proved most effective in preventing or retarding the germination and growth of seeds? Support your answer.
 - g. Select five seeds with the longest roots from each of the petri dishes and measure the length of the root at the end of the 72-h period. Calculate the mean growth of the root. Put your results in the observation table and then make an appropriate bar graph of your results.

Check your answers by turning to the Appendix, Section 2: Activity 3.

In this activity you have discovered why organisms compete among themselves and with other organisms. You should be able to identify the different types of competition. You should also be able to examine a symbiotic relationship and describe how each organism in the relationship is affected. With this information, you can now classify the symbiotic relationship.

Follow-up Activities

If you had difficulty understanding the concepts in the activities, it is recommended that you do the Extra Help. If you have a clear understanding of the concepts, it is recommended that you do the Enrichment.

Extra Help

In order to survive in the biosphere, all organisms must process matter and energy. For some species this is quite simple. Do you remember the autotrophs you studied in Biology 20 who obtained matter and energy from abiotic factors like water, carbon dioxide, and sunlight? Many organisms require other organisms for their matter and energy. This leads to many intricate relationships amongst species and results in pressure to adapt and survive.

You can examine some examples of adaptations by viewing microslide set 218, Mechanisms for Survival. View each of the microslides and read the accompanying brochure. Use this information to answer the following questions.

Observe Slide 1.

1. What three adaptations did the moth inherit to help it escape predation?
2. Why would the allelic frequency for these beneficial traits in the moth population be high?

Observe Slide 2.

3. What adaptive behaviour is demonstrated by the mites?

Observe Slide 3.

4. How do the insects in this slide protect themselves from predation?

Observe Slides 5 and 6.

5. What mechanism is being used by the fly and the moth in these slides to improve their chances of survival?

Observe Slides 7 and 8.

6. How do the insects shown in these slides increase their chances of survival?

Check your answers by turning to the Appendix, Section 2: Extra Help.

The interactions between organisms in an ecosystem can be very complex. If you examine two organisms that have some direct effect on each other, you can classify the role or relationship using the following terms: *predators, prey, commensalism, mutualism, parasitism, interspecific competition, or intraspecific competition.*

7. To gain a better understanding of these terms, use them to classify the following roles and relationships.
- One organism benefits, while the other is not affected. _____
 - These organisms kill for survival. _____
 - This relationship occurs where an organism requires a host. _____
 - Both organisms benefit in this relationship. _____
 - This relationship involves competition where two different species require the same niche. _____
 - This is the role of mule deer in the food chain with cougars. _____
 - This relationship involves two organisms from the same species competing for a limited need. _____

Check your answers by turning to the Appendix, Section 2: Extra Help.

Enrichment

Predator-prey relationships can be affected by human activities that unexpectedly expose a vulnerable species. You learned this when you studied the mountain caribou research project. Logging practices increase habitat for deer and moose. As deer and moose populations increase, wolves increase. Unfortunately, wolves prey on caribou which are more vulnerable than moose or deer. Caribou populations decline.



Read the following article on raccoons and nesting sea birds; then answer the questions that follow.

Raccoons Destroying Queen Charlotte Sea Birds, MP says

PETER O'NEIL
Vancouver Sun

Ottawa

Raccoons threaten to devastate the Queen Charlotte Islands' sea bird population, according to a federal MP and a new government study.

Raccoons invade nesting grounds at night, tearing off the birds' heads and frequently eating only a fraction of the numerous birds killed during the frenzy.

"There are wounded, maimed, brutalized, bleeding adults and chicks all over the place," New Democratic Party environment critic Jim Fulton (Skeena) said Tuesday.

"It's a scene of carnage and it needs to be stopped."

Ugly sewer rats are equally vicious in their attacks on nesting birds, and a \$1-million poisoning program to deal with rats on Langara Island is planned for 1995, pending federal and provincial approvals. But there are only preliminary plans to deal with the raccoons, even though an unchecked raccoon population would wipe out the 100 sea bird colonies within the next 20 years, said Gary Kaiser of the Canadian Wildlife Service's B.C. office.

"Raccoons in the Queen Charlotte Islands pose a severe threat to colonial seabirds in the archipelago," concludes a study completed this month by Ottawa's National Wildlife Research Centre. But possible opposition from animal rights groups is causing government foot-dragging on an eradication program, Fulton said.

"The federal and provincial governments should stop dithering and get on with the demise of the predators," Fulton said.

Federal and provincial officials will meet in November to determine how to control the voracious

raccoon population, which has already devastated two major sea bird colonies on the Charlottes.

Officials are considering a plan to shoot or trap raccoons which sometimes swim several kilometres to remote islands to gobble up nesting birds, Kaiser said. It could start in 1994.

Neither the rats nor the raccoons are indigenous to the Charlottes. The rats came from visiting ships, while the raccoons appeared in 1948 as part of a fur-farm experiment. It didn't work out and the animals were released.

But fears that protests from animal rights groups are delaying political action, particularly with regard to the raccoon plan, according to Fulton.

"A lot of people have a much cozier feeling towards raccoons than they do about rats," he said.

"Here you have what many people consider to be this cozy, furry, friendly little critter that's in there slaughtering by the thousands unprotected, immature birds, some of which are very much endangered."

Kaiser said society has an obligation to correct what he calls an ecological "crisis" created by humans who introduced the rats and raccoons.

"There is an ethical issue here: human beings have screwed up a natural environment" on the Charlottes, he said.

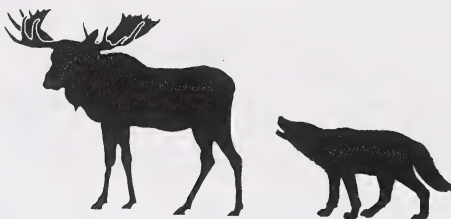
The raccoon problem wasn't discovered until a 1986 federal sea bird colony inventory detected a suspected destruction by raccoons of a colony of several thousand ancient murrelets on Saunders Island, off the coast of South Moresby.

The rapid and violent disappearance of sea birds was confirmed in a 1992 study. A new study this month showed that the 1986 population of 26,000 sea birds on Helgesen Island, which neighbours Saunders, has been reduced by more than 80 per cent because of raccoons.¹

1. a. Describe the damage being done by the raccoons.
- b. Where did the raccoons originally come from?
- c. What other predator is also impacting on nesting bird colonies?

¹ *The Vancouver Sun*, for the article "Raccoons Destroying Queen Charlotte Sea Birds, MP says," by Peter O'Neil, July 28, 1993. Reprinted with permission of *The Vancouver Sun*.

- d. A natural solution to the predation on nesting birds would be to eliminate the raccoons. Describe the issue that is delaying this action.
- e. Compose an argument for and against elimination of the raccoons.
- f. Describe the ethical issue hinted at in the article.



Science Skills

- ☐ A. Initiating
- ☐ B. Collecting
- ☐ C. Organizing
- ☒ D. Analysing
- ☒ E. Synthesizing
- ☐ F. Evaluating

There is a large island (544 km²) in Lake Superior that is a national park. The moose and wolves of Isle Royale are protected there. Moose and wolves appeared on the island in the 1940s and remained relatively stable. From 1970 to 1980, both populations fluctuated but the general trend was an increase in the wolf population and a decrease in the moose population. From 1980 to 1982, the number of wolves dropped dramatically to about 1/4 of the previous numbers. Research determined that these wolves died mainly from starvation.

2. From what you have learned in this section, propose an hypothesis that explains these observations and predicts future changes in both the moose and wolf populations.

Science Skills

- ☒ A. Initiating
- ☒ B. Collecting
- ☒ C. Organizing
- ☒ D. Analysing
- ☒ E. Synthesizing
- ☒ F. Evaluating

3. Research the concept of keystone predatory species and then defend or refute the following statement. "The purpose of a keystone predator in an ecosystem is to prey upon the most abundant prey species in order to prevent it from competitively excluding other species." An excellent article to begin with can be found in the November 1991 *Equinox*.

Check your answers by turning to the Appendix, Section 2: Enrichment.

Conclusion

No organism lives in isolation. All living things interact with other living organisms in an ecosystem. You have learned about the relationship between predators and the animals they prey upon. You examined how prey species have developed special strategies to avoid predation. Competition between organisms is the driving force for evolution and you have learned about some types of competition. Finally you learned about how organisms live together symbiotically and how these relationships must have co-evolved over long periods of time.

Section 2 Assignment: Interactions and Relationships

Review the Evaluation information found in the introductory pages of this module.

It is important to number and clearly identify each page with the following information at the top:

Biology 30 – Module 6

Section 2 Assignment

Page #

Name and ID#

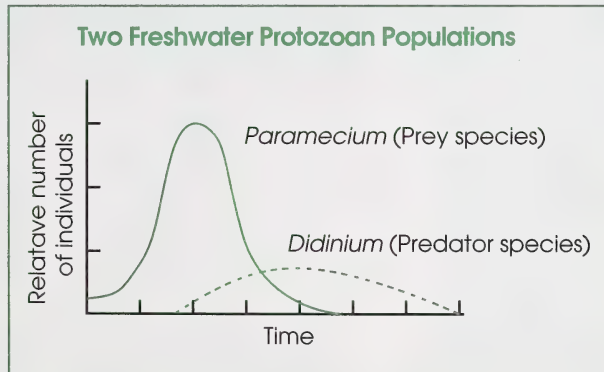
Be sure to write legibly. Leave a wide left margin and number all of your pages.

Carefully read each of the following multiple choice questions and decide which of the choices **best** completes the statement or answers the question. Each question is worth 1 mark.

1. A prey population
 - A. is adapted to escape the predator
 - B. is larger in biomass than the predator population
 - C. has a particular niche
 - D. all of the above

An experimental situation was set up to examine a predator-prey relationship. The populations of both are represented in the following graph.

Use the following diagram to answer questions 2 and 3.



2. In this experimental situation, what reason can be given to explain why both the prey (*Paramecium*) and predator (*Didinium*) populations died out?
 - A. The predator population should have been added earlier.
 - B. The predator population should have been given escape cover.
 - C. The prey population should have been added earlier.
 - D. The prey population should have been given escape cover.

3. In this experiment, the predator and prey both dying out illustrate that
 - A. competition exists in the lab but not in nature
 - B. symbiosis is a universal happening
 - C. laboratory experiments are not always like natural conditions
 - D. the prey population is maintained in spite of predation
4. The gypsy moth population, an introduced species that feeds on trees, has grown too large. Which of these could be the reason for the large population size?
 - A. lack of gypsy moth predators
 - B. lack of competition from other insects
 - C. lack of defence on the part of trees
 - D. all could be reasons for the population growth
5. When predator and prey species co-evolve, the population size of both
 - A. is maintained
 - B. decreases
 - C. increases
 - D. depends on whether the prey is itself a predator

Use the following information to answer question 6.

An ecological system was studied over a period of years and the energy content (expressed as kilocalories) of several species was determined. You may consider the energy content as equivalent to the total biomass produced in that year and should recall the concept of biomass from Biology 20.

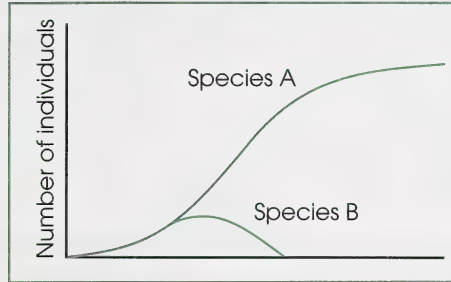
Caloric Equivalents of Biomass ($\times 10^3$ Kcal)					
Species	1987	1988	1989	1990	1991
1	19	23	18	41	17
2	438	450	420	720	397
3	103	120	130	564	143
4	111	110	141	301	117
5	1	0.5	0.1	10.1	7.6
6	28	34	37	56	37
7	600	705	713	1065	782
8	113	75	141	138	76

6. The species that is most likely to be a predator is
 - A. 2
 - B. 3
 - C. 5
 - D. 7

7. Gause's principle is an example of

- A. interspecific competition
- B. intraspecific competition
- C. commensalism
- D. parasitism

Use the following graph to answer question 8.



8. Which species can be considered successful?

- A. Species A
- B. Species B
- C. both Species A and B
- D. neither of Species A and B

9. A population of roundworms lives in the lymph vessels of a human where it gets nourishment. When a mosquito bites an infected person, roundworms are taken up and then passed on to other humans. This is a description of

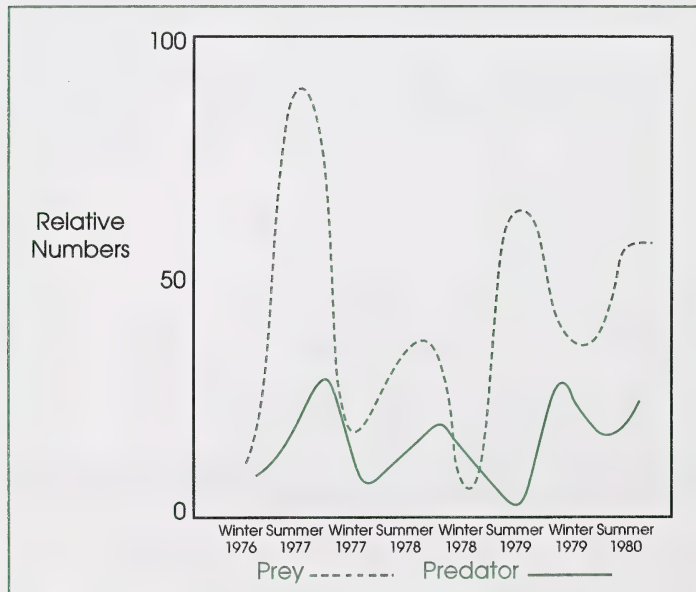
- A. competition
- B. predation
- C. parasitism
- D. mutualistic commensalism

10. Which is an example of mimicry?

- A. sitting still, attracting little attention
- B. pufferfish doubling their size when scared
- C. a harmless grasshopper that looks like a bad-tasting one
- D. algae and fungi living together in a lichen

11. An example of an interaction between two individuals of different species in which one benefits while the other incurs a continuing loss is
- A. mutualism
 - B. parasitism
 - C. competition
 - D. symbiosis
12. Leaf cutter ants keep fungal gardens. The ants provide food for the fungus on which they feed. This is an example of
- A. competition
 - B. predation
 - C. commensalism
 - D. mutualism
13. Territoriality, the establishment of a home range occurs as a result of
- A. predation
 - B. parasitism
 - C. competition
 - D. cooperation

Use the following graph to answer questions 14, 15, and 16.



14. The oscillations in the predator-prey populations primarily occur because
 - A. an increase in the prey population will increase the predator population indefinitely
 - B. an increase in the prey population will allow for an increase in the predator population until the prey population is reduced
 - C. an increase in the predator population causes an immediate increase in the prey population
 - D. of seasonal changes
15. The most mild winter probably occurred in which year?
 - A. 1976
 - B. 1977
 - C. 1978
 - D. 1979
16. In the winter of 1980, a toxic chemical, fatal to the prey but not the predators, is introduced into the environment. The result on the predator population will be
 - A. minimal as the chemical has no effect on the predators
 - B. a drop in numbers due to the decreased availability of food
 - C. rise as there is now a lack of competition
 - D. nil as the populations are not connected
17. An animal that uses camouflage as a method of avoiding predation will probably demonstrate which of the following?
 - A. startle behaviours
 - B. toxic chemicals
 - C. motionless behaviour
 - D. alarm responses
18. Commensalism is an interaction between two species in which
 - A. both are harmed
 - B. both benefit
 - C. one benefits and the other is unaffected
 - D. one benefits and the other is harmed

Use the following information to answer questions 19 and 20.

A student performed the following experiment after observing the lack of other vegetation surrounding a plant commonly known as "pussy toes." The plant is found growing in grassy areas, especially in areas that are used for pasture. The student picked off the leaves of the plant and blended them with 100 mL of distilled water. The mixture was allowed to sit for one hour and then was filtered to collect an exudate. This liquid was then used to moisten grass seeds and the subsequent germination was noted.

19. Classify the following statement. "If the grass seed germination is reduced when watered with the exudate, then the pussy toes produce a chemical that inhibits the growth of other plants."
- A. problem
 - B. hypothesis
 - C. observation
 - D. interpretation
20. The competitive advantage that is being investigated is referred to as
- A. intraspecific competition
 - B. interspecific competition
 - C. Gause's principle
 - D. allelopathy

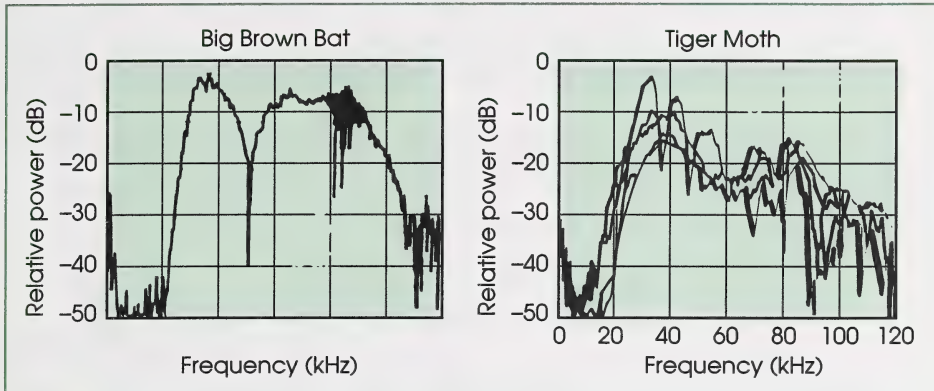
Science Skills	
☒	A. Initiating
☐	B. Collecting
☒	C. Organizing
☒	D. Analysing
☐	E. Synthesizing
☐	F. Evaluating

21. A population of great horned owls (*Bubo bubo*) in a 160 km² area in central Alberta increased over a three-year period (1966-69) from ten to eighteen birds. The population of snowshoe hares (*Lepus americanus*) increased seven times. The portion of nesting owls increased from 20% to 100%. The amount of hares in the owl's diet increased from 23% to 50%.
- a. Write a problem that clearly identifies the manipulated and responding variables. **(1 mark)**
 - b. Present this data in a table. **(2 marks)**
 - c. Identify two variables that should remain fixed or constant during this research in order to produce reliable results. **(2 marks)**
 - d. Using the data, write a conclusion that explains the result gathered. **(3 marks)**

Reproduce the science skills assessment box after your response to this question. Remember to indicate your evaluation of your skill level for each identified science skill. Be sure to include the spaces for teacher assessment.

Self: A.	☐	B.	☐	C.	☐	D.	☐	E.	☐	F.	☐
Teacher: A.	☐	B.	☐	C.	☐	D.	☐	E.	☐	F.	☐

22. The following graphs compare the frequency of cries emitted by the big brown bat (*Eptesicus fuscus*) and a frequent prey, the tiger moth.



- What is the purpose behind the signals emitted by the tiger moth? (2 marks)
- Use this relationship to describe the co-evolution of the big brown bat and the tiger moth. (4 marks)

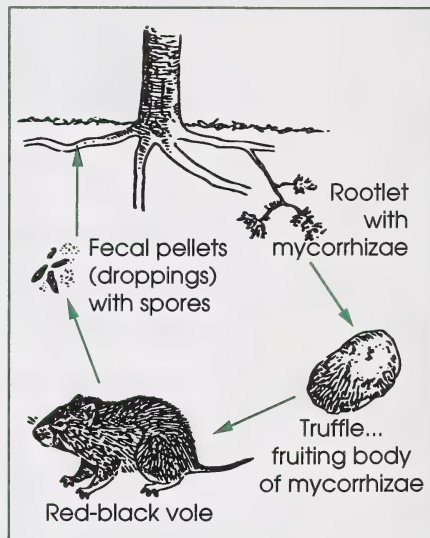
Use the following information and data to answer question 23.

23. The moose of Elk Island National Park are prone to infestations of the winter tick (*Dermacentor albipictus*). A healthy adult moose can carry 10 000 ticks with no debilitating effects. During severe tick infestations, ticks may number up to 100 000 on host individuals during the winter months. These population levels have serious effects on the host animal through blood loss and stress caused by a change in moose behaviour. Rather than feed, the moose spends much of its time rubbing against trees in an attempt to remove the ticks. This rubbing action breaks off and removes hair from the body leaving bald, whitish areas. The extent of hair loss is being studied in an attempt to relate it to the level of infestation and the general health of the moose population.

Year	Park Moose Population	Average Number of Ticks per Moose
1987	126	15 000
1988	158	40 000
1989	204	112 000
1990	102	8 000
1991	115	9 000

- a. Plot a line graph for the data. The title of the graph should read "A Comparison of Moose Population and the Level of Tick Infestation in Elk Island National Park from 1987 to 1991." (3 marks)
 - b. Write an hypothesis based on the preceding information and data. Be sure to describe the relationship between the ticks and the moose. (2 marks)
24. Interpret the following analogy. "Predation lives on the capital while parasitism lives off the interest." (2 marks)

Fungi often play an extremely important mutualistic role for some types of trees. The fungi have a root system known as mycorrhizae. The mycorrhizae have beneficial effects on the trees that they live around. The mycorrhizae decompose organic material producing nitrogen, increase the absorption capabilities of the tree, reduce the susceptibility of the roots to invasion by pathogens, and secrete antibiotics that help the tree grow and stay healthy. The tree supplies the fungi with carbohydrates from the roots as a food source. The relationship is not even this simple. In most forms of mutualism there are two organisms within a relationship that benefit each other. In this case there is another organism that is required to make an interesting circle complete. Examine the diagram on the right and answer the question that follows.



25. As you have read, the role between the mycorrhizae and the tree is mutualistic. Explain the essential role of the red-black vole in this three-way relationship. (2 marks)
26. Summarize the following symbiotic relationships in the chart using the given symbols. The order of the symbols is not significant.
- + to indicate that the organism benefits
 - to indicate that the organism is harmed
 - 0 to indicate that the organism is unaffected

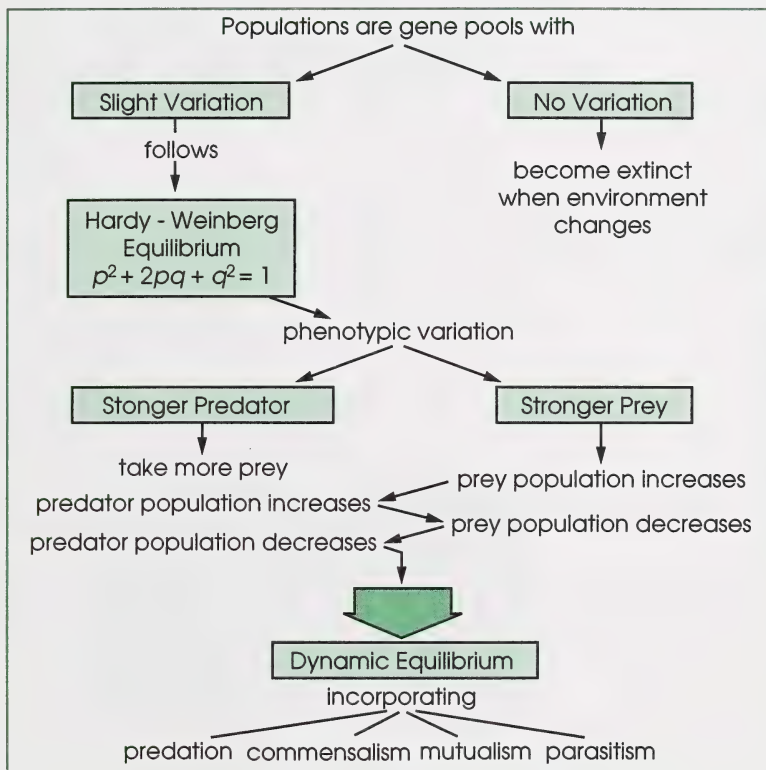
Organism A/B	Relationship
	commensalism
	predation
	mutualism
	parasitism

(2 marks)

MODULE SUMMARY

In this module you have studied the link between genetics and populations. This is the concept of a gene pool. With a knowledge of the principles of heredity, you can appreciate how characteristics and variations are passed to the next generations in a population.

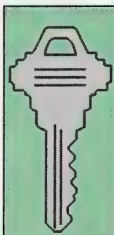
An understanding of how populations interact shows you how gene pools flex their molecular muscles. Spared from the unfortunate consequences of human exploitation, there may always be a balance of organisms dependent on each other in the biosphere.



To ensure that all of your work has been completed in a satisfactory manner, check off the items in the following list:

- ☐ Section 1 Assignment has been completed.
- ☐ Section 2 Assignment has been completed.
- ☐ Your responses are organized and neat, with room for teacher comments.
- ☐ All your response pages are numbered consecutively and identified with this heading.

Appendix



Glossary

Suggested Answers

Glossary

allelopathy: a chemical method that plants use to compete with other plants

biodiversity: the maintenance of the variety of living things in the biosphere

biological control: a method of controlling an organism’s population by using a predator or parasite

exudates: any chemical released by an organism

ecological reserve: habitat set aside in perpetuity to preserve a representative ecosystem

resource partitioning: the use of spatial or temporal behaviours to separate similar niches occupied by similar species; e.g., hawks and owls both eat small rodents but the owls hunt at night and the hawks during the day.

Suggested Answers

Section 1: Activity 1

- 1. Darwin’s book *On the Origin of Species* would have been complemented by Mendel’s work because Darwin could not explain the source of variations or how they were passed on. Mendel was the one who would have laid the groundwork for this concept in his work on genetics.
- 2. The three key ideas of the modern theory of evolution are as follows:
 - Variation is due to differences in a population’s genes.
 - Mutations can cause new variations to occur.
 - These variations are passed on to future generations.
- 3. Biodiversity is a very valuable resource because the varying genetic makeup of individuals allows for differences essential for species adaptation and natural selection.
- 4. The expected results would be approximately 65% tongue rollers if a large sample size was used. Your results will vary greatly depending on the number of individuals sampled. If you only sampled ten people, the percentages would probably be quite different from the normal 65% tongue rollers. Your results might also be quite different if your sample was from a group of people who were closely related.
- 5. Family members could all be the same because they all possess the same types of genes. Your family members are all part of the same gene pool, which means the same characteristics can be expressed within a family. Your family can all probably roll their tongues or they all probably can’t. Recall from your study of genetic inheritance the following inheritance cross.

P ₁	RR × RR	RR × Rr	RR × rr
	↓	↓	↓
F ₁	all roll	all roll	all roll
P ₁	Rr × Rr	Rr × rr	rr × rr
	↓	↓	↓
F ₁	3 roll: 1 can’t roll	1 roll: 1 can’t roll	all can’t roll

Key

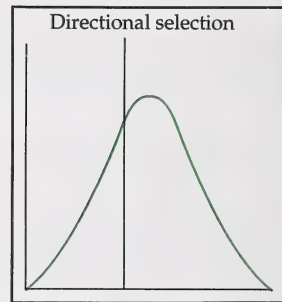
R: roller r: non-roller

Your family will fit into one of these categories.

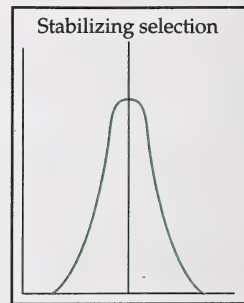
6. The parts of Darwin's theory that most closely relate to the concepts you are studying now are the idea of variation within a species and the passing of these variations to subsequent generations.
7. Three forms of adaptation are structural (such as the pentadactyl limb in mammals), physiological (such as chemicals in the pitcher plant), and behavioural (such as the migration of the Canada goose).
8. The two types of mutation that can occur are chromosome mutations when gametes are lacking or having an extra chromosome and gene mutations when information within the strands of DNA is altered.
9. Mutations are very rare events in individuals; but because you have so much DNA in each of your genes on your forty-six chromosomes and because of the large numbers of humans on the planet, the chances of at least one mutation occurring within the human gene pool is great.
10. Your graph should show a curve that is pushed to the right.

You should keep in mind that if the selective forces acted upon the population represented by the right side of the graph, the mean would shift to the left.

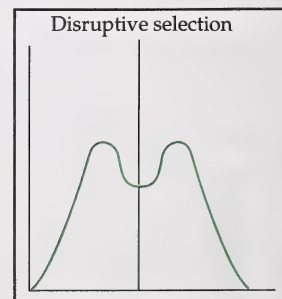
11. The fossil record of the length of a giraffe's neck could be used as an example of directional selection. Giraffes once had short necks but the selective force of competition for food high in the trees allowed those with longer necks a better chance for survival.



12. The base of the curve will be narrower.
13. An example of stabilizing selection could be the body design of sharks. Those who are marked differently from the norm are selected against because the shark perfectly fits its niche. The results after stabilizing selection are that the population distribution becomes narrow because the individuals on both ends are selected against. This stabilizing effect or the reducing of variation within the population could result in the extinction of the species if the environment changes and adaptation is impossible.



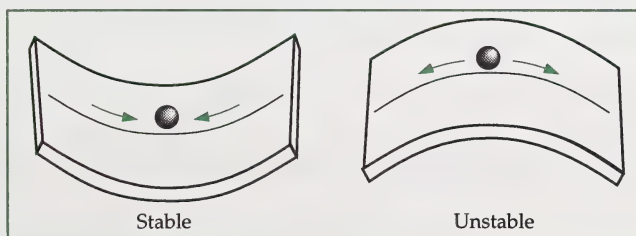
14. Your graph should look like the third one on the right.
15. Disruptive selection can occur whenever the norm of the population is selected against. This usually happens when a geographic separation occurs and the environments are so different that the extremes of the population are selected for. An example would be the snakes of North America. Due to geographic separation, the same species has changed so that the snakes have different appearances in various parts of the continent. In disruptive selection the high percentage group of the population is selected against. This will result in the numbers of individuals in the population increasing on either side of the non-selected group. If these changes continue the population will be split into two distinct groups.



16. Speciation is any process that would cause the development of a new species. One process is disruptive selection.
17. Natural selection and speciation are not always the same thing. Natural selection can occur in a very simple trait within a species such as the colouring of fur, but in no way would this constitute a change in species. Speciation takes many generations and many different changes in characteristics.
18. A species is defined by the ability of the individuals to breed and produce fertile offspring with natural barriers and conditions in place. In zoos, tigers and lions can breed producing a liger. These two distinct species do not live in the same habitat; therefore, this is not a natural situation. Different species would be unable to mate due to the populations living in different habitats, having their breeding seasons at different times, demonstrating different behaviour patterns before mating, through incompatible reproductive structures, or through the production of a sterile offspring.
19. As you have read, geographic isolation will occur if there is a physical obstacle which separates a population thereby preventing them from breeding and not allowing gene flow to occur. The mice population could be separated if the farmer were to put in a wide irrigation ditch through the middle of the field. To allow for speciation to occur, different environmental factors must be present on the two sides. One side could be planted with the same crop as was growing before the irrigation ditch was constructed. If the other side was planted with a much different crop that provided a much different food source and less shelter from predators, the population would have to adapt to the new food source and find ways to hide or protect themselves from the predators or they would face extinction.
20. Reproductive isolation might still be in effect if the two species remain in their separate habitats, if mating behaviour is markedly different, or if the two species together are capable of only producing sterile offspring.

Section 1: Activity 2

1. The Hardy-Weinberg principle states that under ideal non-changing conditions, allele and genotype frequencies will remain the same from generation to generation within a population. The population draws all its genes from the same gene pool.
2. A term that can be used to express the situation where a population's gene pool remains the same generation after generation is *genetic equilibrium*.
3. If a population is not in genetic equilibrium, then some factor must be causing it to become unstable. This instability can be referred to as evolution. The following graphic allows you to visualize stability and instability as types of equilibrium. If the Hardy-Weinberg equation shows variation from genetic equilibrium, then you may suspect some evolution is occurring.



4. The Hardy-Weinberg equation is $p^2 + 2pq + q^2 = 1$.

Letter	Representation
p	frequency of the dominant allele at a locus
q	frequency of the recessive allele at a locus
p^2	frequency of homozygous dominant individuals within the population
q^2	frequency of homozygous recessive individuals within the population
$2pq$	frequency of heterozygous individuals within the population

Note: You must keep in mind that $p + q$ must always equal 1. It is important that you are comfortable with the variables found within the Hardy-Weinberg equation before you move on to more difficult questions.

5. The Hardy-Weinberg equation is very useful in calculating the frequency of the genotypes if allele frequencies are given, and it can also be used to calculate the allele frequencies if the genotypic frequencies are given.
6. As the Hardy-Weinberg principle states, conditions must be constant for genetic equilibrium to be maintained.
- The population must be large to eliminate the possibility of genetic drift.
 - Random mating must occur where every individual has an equal opportunity of mating. Humans do not exhibit random mating as there are cultural, ethnic, religious, and geographic barriers.
 - No mutations can be occurring as this could change the alleles within individuals.
 - Migration or gene flow cannot occur. If this were to happen new genes could enter the population or certain genes could be removed. This would have an effect of changing the frequencies of alleles.
 - All organisms must be equally viable within the environment and all have an equal opportunity of mating.
7. Typically on a Punnett square, the eggs and sperm represent gametes from the parents. In a Punnett square that shows the Hardy-Weinberg principle, the eggs and sperm represent the frequency of alleles in the entire population.
8. In the F_1 as determined by the text, $A = 0.70$ $a = 0.30$

By using the formula $p^2 + 2pq + q^2 = 1$

$$(0.70)^2 + 2(0.70)(0.30) + (0.30)^2 = 1$$

Then the genotypic frequencies will be $AA = 49\%$ $Aa = 42\%$ $aa = 9\%$

As you can easily tell, the frequencies are the same as previous generations and will continue to be the same if all factors remain the same. Genetic equilibrium has been realized in this population.

9.

$p + q = 1$
 $0.60 + 0.40 = 1$

This rule must be adhered to. The frequency of both alleles must add up to 1.0 or 100%.
- $p^2 = (0.60)^2 = 0.36$

36% of the population is homozygous, *MM*.
- $2pq = 2 \times 0.60 \times 0.40 = 0.48$

48% of the population is heterozygous, *MN*.
- $q^2 + (0.40)^2 = 0.16$

16% of the population is homozygous, *NN*.

10. To answer this question you must first convert the population numbers into percentages or frequencies.

$MM = \frac{52}{200} = 26\%$, $MN = \frac{96}{200} = 48\%$, $NN = \frac{52}{200} = 26\%$.

So $p^2 = 0.26$, $2pq = 0.48$, and $q^2 = 0.26$.

The percentages of the genotypes are different from the genotypic frequency of the whole human population, but what is more important is the comparison of the allele frequencies. Remember $MM = p^2$, $MN = pq$, and $NN = q^2$.

$q^2 = 0.26$, so $q = \sqrt{0.26} = 0.50$. Since $p = 1 - q$, $p = 0.50$ you can see then that the frequency of *M* (or *p*) has changed from 0.60 in the entire human population to 0.50 in the isolated community, and the frequency of *N* (or *q*) has changed from 0.40 in the entire human population to 0.50 in the isolated community. The change could be due to some type of evolution occurring, but this is highly unlikely due to the relatively short period of time that the population has lived together. The probable cause of the change is that one of the conditions specified by Hardy and Weinberg was not maintained, and that is that the population is too small for application of this principle.

11.
- **Textbook question a:** The genotypes of the offspring are Hb^A , $2Hb^A Hb^S$, and $Hb^S Hb^S$.

- i.

The probability is 3/4.
- ii.

The probability is 1/4.

	<i>Hb^A</i>	<i>Hb^S</i>
<i>Hb^A</i>	<i>Hb^A Hb^A</i>	<i>Hb^A Hb^S</i>
<i>Hb^S</i>	<i>Hb^A Hb^S</i>	<i>Hb^S Hb^S</i>

- **Textbook question b:** Normal parent ($Hb^A Hb^A$) × carrier parent ($Hb^A Hb^S$) = all offspring are normal.
- **Textbook question c:** All offspring will be homozygous for the dominant condition. There is also little chance that they would have had offspring. Most would have died prior to reproductive age.
- **Textbook question d:** It demonstrated that the heterozygous phenotype was related to the sickling condition which was expressed by the homozygous recessive genotype. Under conditions of very low oxygen even individuals who are carriers will be affected.
- **Textbook question e:** They are resistant to malaria, a parasitic infection.
- **Textbook question f:** The sickle-cell gene would eventually disappear, since there would no longer be any advantage in being a carrier. However, this would take a number of generations.
- **Textbook question g:** The mosquito that carries the disorder is being controlled. Also many individuals may have migrated to areas where the mosquito that carries malaria is not found.

12. • **Textbook question h:** No, the ratio of the Tay-Sachs genotype to the general population is much lower than $1/4$. The next generation should yield the same results unless the tt condition that causes Tay-Sachs provides some environmental disadvantage or some advantage.
- **Textbook question i:** Otherwise the homozygous recessive individual would have the disorder and would not live long enough to reproduce.
- **Textbook question j:** Both are caused by an abnormal protein (enzyme). In both cases the DNA sequence has been altered.
- **Textbook question k:** Individuals with tt have motor coordination problems and often convulsions and often die before age four. Also the tt genotype present is only 0.028% of the population.
- **Textbook question l:** The tt genotype often caused severe deterioration of the nervous system or death, while the Tt condition may have provided resistance against tuberculosis.
- **Textbook question m:** Individuals with the heterozygous genotype have an increased resistance to TB and so survive to reproduce.
- **Textbook question n:** It may indicate that migration from this population was restricted or that some other environmental factor may have occurred in this area. This group's genotype may have been susceptible to these environmental influences.
13. • **Textbook question o:** The environment likely induces numerous gene mutations – mutations, though, are not universal.
- **Application question 1:** The environment selects certain genotypes. Genotypes that are deleterious in the homozygous condition continue to remain part of the gene pool because their heterozygous condition provides some selective advantage. In other words, carriers have an advantage. This keeps the recessive allele in the gene pool.
- **Application question 2:** The couple should be informed about the chances that a child would have the homozygous recessive condition. Treatment for the homozygous recessive condition could also be explored.
- **Application question 3:** The recessive disorders can provide a selective advantage in the heterozygous condition. The heterozygous condition requires that some genes remain in the gene pool. The mating of heterozygous individuals, by chance, will produce some homozygous recessive individuals. You cannot produce a 100% heterozygous population.

Section 1: Activity 3

1. The rate of extinction has rapidly increased due to the loss of habitat. This habitat is critical to the maintenance of species as it provides for the necessities of life, such as food, shelter, water, and so on. In some situations it is just the loss of breeding habitat that is enough to significantly reduce a species' numbers.
2. A keystone species is one that has a profound influence on many other species in an ecosystem. If this species is lost from the ecosystem, a profound change occurs in the species diversity or composition of the ecosystem. In many cases the keystone species could be a plant. Think about food chains and food webs.

- 3. Diversity is critical to maintaining any species because it maximizes the genetic variation within the population. The variation within the population provides the species with the ability to adapt to the inevitable slow changes in the environment that occur as time passes. Without this genetic variability, change may bring about a rapid disappearance of a species due to its lack of fitness for the new environment.
- 4. Over your lifetime, the answer would be yes, but if you look at the question over a greater time scale, the answer is no. Change is a fundamental fact of life. Ecosystems change slowly as the planet experiences climatic changes, and the organisms within an ecosystem will change also. Some will find the new conditions more advantageous and become more dominant. The only constant is that there will be change.
- 5. The goal behind establishing ecological reserves is to set aside and maintain enough of a representative ecosystem that the biological diversity or genetic variation within the gene pool will be sufficient to allow the ecosystem to respond to natural changes. If the genetic variation is present, then the population of organisms will be able to adapt.
- 6. Large ecosystems have organisms within them that are specially adapted to that environment. If the ecosystem is fragmented or broken into separate pieces, a geographical barrier is formed between the areas. Some of the members of the ecosystem will become isolated, preventing them from interacting with members of their own population as in breeding. An interesting example from the article was the discovery that the construction of a road through the ecosystem introduced a barrier to insect movement. This resulted in decreased pollination of certain plants and lower reproductive success among those plant populations. Do you remember the description of keystone species from the previous article? The other major concern of fragmentation is the increased habitat for those organisms that find the edges of the habitat more advantageous to their nature. An example from the prairies is the loss of upland habitat around sloughs. This loss of habitat has caused the waterfowl to concentrate their nesting in the limited area immediately surrounding the water's edge. Predators have taken advantage of this by changing their search patterns to concentrate on the slough edges. This has resulted in increased predation, decreased nesting success, and an overall decline in the waterfowl population.
- 7. The winter range of the caribou has decreased. It appears to be a 10% to 20% loss.
- 8. With decreased winter range, the food supply becomes more limited thus adding more stress to the population in its struggle to survive. As mentioned in the fragmentation article, it will now be easier for predators to find the caribou as prey.
- 9. From the winter range map it appears that the caribou have abandoned their previous winter range and adopted a new one further east.
- 10. It is quite probable that this study has not been conducted for a long enough period in order to fully understand range preferences of this herd of caribou. The other possibility is that some factor drove them out of the previous winter range.
- 11.
 - a. The plains and wood bison interbred successfully when allowed to mix in Wood Buffalo National Park.
 - b. The offspring can only be classified as hybrids.
 - c. The wood bison discovered in 1957 had never interbred with plains bison. They were still a pure and distinct species or at least a distinct subspecies.
 - d. The bison are kept apart to prevent interbreeding and to maintain two separate species.
 - e. Controlled burning of forest areas creates grassy areas for plains bison.

- f. Protected in a park, the bison population could increase to the point of consuming all available food. Starvation and disease would result.
- g. Excess bison are made available to wildlife agencies, the public, and zoos.
- h. The slaughter of bison effectively separated the bison into two groups with no intermediate individuals showing the gradual change (clinal variation) in the entire bison population from the south to a more northern environment. This subtle loss of variation, resulted in two populations of bison that have significant morphological (structural) differences.

A similar model for explaining this can be constructed using the domestic dog. All dogs belong to the same species (*Canis familiaris*). Due to the great size difference though, German shepherds cannot breed with toy poodles. If you wanted to add a specific trait from toy poodles into the German shepherd gene pool, you would have to accomplish this task by using intermediate-sized dogs. If all other dogs were destroyed with the exception of toy poodles and German shepherds, the morphological differences between them would be so great that one would not even consider them to be of the same species.

- i. This is called disruptive selection.
 - j. In the first scenario the ancestral bison population splits into two new species, plains bison and wood bison. In the second scenario the ancestral bison evolves into the plains bison. Later some of the plains bison evolve into wood bison. Hybridization is more likely in the second scenario where the wood bison could be seen as a distant offspring of plains bison. This is supported by how easily plains bison and wood bison interbred in Wood Buffalo National Park.
12. a. How do environmental conditions (**manipulated variable**) affect the appearance (phenotype) of bison (**responding variable**)?
- b. According to the hypothesis, if the environment is the same, then the morphology of the two groups should also be the same. As the wood bison population in Elk Island National Park has been there for approximately thirty years, it should be very simple to compare them to the plains bison on the other side of the park. You could also compare these captive wood bison in Elk Island National Park with individuals that have been moved back to northern Alberta and the NWT to see if any changes have occurred between these two groups. Another procedure could be the use of a Hardy-Weinberg analysis to see if there has been genetic drift.
13. Examples of organisms that have rebounded from small populations are whooping cranes, bison, and swift foxes. All of these organisms have started with few individuals. As a result, there should be little variation between individual variations in the new populations.
14. Genetic variation in a population can only be increased through two methods. One is to bring in breeding individuals from another population. The other is through the process of mutation.
15. Mutations occur at random and, as learned earlier, are usually lethal. To have a mutation occur that is advantageous and is selected for by the environment may take a long time.
16. The hourglass model should be a good explanation as to why there is very little genetic diversity within the bison populations. After the extensive slaughter the plains bison have returned from a very small founding population (hundreds). You would expect these results. The wood bison population was never very large; therefore, it would also be expected to have very little variation.

- Isolation has prevented these populations of bison from exchanging genetic information. As for the hybrids that exist in Wood Buffalo Park, they probably best represent the intermediates that existed between the wood bison and the plains bison.

Section 1: Follow-up Activities

Extra Help

- Darwin could have used Mendel's discoveries by learning that units of **heredity** are not blended together in the offspring, but are **preserved** within each succeeding generation.
- Many scientists felt that recessive phenotypes would be **eliminated** by the dominant genes that were found in large populations. This hypothesis was found to be incorrect. The recessive genes will always be **maintained** in large populations as is stated in the **Hardy-Weinberg** principle.
- The mathematical binomial theorem was applied to biology by Hardy and Weinberg. The formula is $p^2 + 2pq + q^2 = 1$.
- The conditions for the proper functioning of the Hardy-Weinberg equilibrium are that a large, **isolated** population must have **random** breeding and no internal or **external** forces acting on the population.
- If the dominant allele, R , is replaced with p and the recessive allele, r , is replaced with q , the Punnett square will look like the following when two heterozygous individuals are mated.

	R	r
R	RR	Rr
r	Rr	rr

	p	q
p	pp	pq
q	pq	qq

From this correlation the Hardy-Weinberg equation was developed as $p^2 + 2pq + q^2 = 1$.

- If $p = 80\%$ or 0.80 , then $q = 1 - 0.80 = 0.20$ or 20% .
Homozygous dominant is $p^2 = (0.80)^2 = 0.64 = 64\%$.
Heterozygous is $2pq = 2(0.80)(0.20) = 0.32 = 32\%$.
Homozygous recessive is $q^2 = (0.20)^2 = 0.04 = 4\%$.
- Meiosis causes an **increase** in variations within a population.
- A **gene pool** can be thought of as an enormous reservoir of genetic information.
- Organic evolution is defined as the change in **frequency** of alleles within a population as described by Hardy-Weinberg.

10. The portion of the population that natural selection tends to favour is the **average** group of individuals. This is referred to as **stabilizing** selection.
11. When one extreme is favoured, **directional** selection results causing the norm of the population to **shift** toward that favoured characteristic.
12. Disruptive selection will result in **speciation** because the norm of the population is selected against causing an increase in the population at the two **extremes**.
13. A species is defined as a group of organisms that is capable of successfully **breeding** while occupying the same **niche**.
14. The gene frequency of a small population that has become isolated may rapidly change due to the **decreased** probability of random mating. In this case, when random mating is lost, the Hardy-Weinberg principle is not valid. This process of change is called **genetic drift**.

Enrichment

1. Probability can only predict what should happen in any given event. It cannot predict what will happen in any given event.
2. The odds for obtaining a seven when a pair of dice is rolled is $6/36$ or $1/6$ or 16.7%. Try rolling a pair of dice thirty-six times. You should get close to obtaining a seven six times.
3. Mendel's two major contributions to genetics were the laws of inheritance and applying the concept of probability to biology.
4. The genetic concepts that need to utilize probability are the Punnett square, the Hardy-Weinberg principle, cross breeding, and phenotypic predictions of offspring.
5. Mathematical techniques are essential in the analysis of data so that biologists can make better and more informed interpretations of their experiments.
6. X^2 represents the discrepancy between a set of expected values and those values obtained by observation. It is important to note that the expected values are based upon an hypothesis of the problem at hand.
7. The chi-square formula is $X^2 = \Sigma (O - E)^2 / E$. For each set of data $(O - E)^2 / E$ is added. If there were two sets of data, $(O - E)^2 / E$ would be calculated for each set and then added together.
 - X^2 is the discrepancy between values.
 - Σ is the sum of all the values following.
 - O is the observed numbers from the data set.
 - E is the expected values from the hypothesis.
8. A less-than-5% probability would mean that some outside force other than chance affected the results of the experiment. The next step is to go looking for the outside cause or force.
9. To determine the percentage of probability, you must first calculate the X^2 value for your data. Take this value and the number of classes or probable outcomes to Table 24.2 on page 565 of your textbook and scan down to the probability line of the table.

10. Problem – Is the presence or absence of the sickle-cell anemia gene associated with the presence of malaria parasites?

Hypothesis – Carriers of the sickle-cell anemia gene have a high survival rate in areas where malaria is present.

Conclusion – Through the analysis of the data using the chi-square test, the probability that the sickle-cell anemia gene has remained in the population by chance alone is less than 1%. This would confirm the hypothesis that carriers of the sickle-cell anemia gene have a high survival rate in areas where malaria is present.

11. Your experiment should follow this basic design; the information within the answer is only an example of what you could have done.

Problem – How many times will the buttered side of a slice of toast land up or down when tossed into the air ten times?

Hypothesis – There is a correlation that the buttered side always lands down.

Background Information – When a slice of toast is being buttered and accidentally falls on the floor, inevitably the buttered side lands down so as to make a mess that needs to be cleaned up.

Materials – one slice of buttered toast

Procedure – Toss the slice of buttered toast into the air allowing it to fall freely to the floor. Record the results in a chart and perform the toss a total of ten times.

Observations –

Tossing of a Buttered Slice of Toast										
Trial	1	2	3	4	5	6	7	8	9	10
Buttered Side (U or D)	U	D	D	D	U	D	D	U	D	D

Analysis and Interpretation – Seven times out of ten the buttered side landed down. Three times out of ten the buttered side landed up.

$$X^2 = \sum (O - E)^2 / E = (7 - 10)^2 / 10 + (3 - 10)^2 / 10 = 0.9 + 4.9 = 5.8$$

Using the chi-square chart the probability of the deviation is less than 5% and greater than 1%. Notice that 5.8 lies between 3.841 and 6.635 on the two classes line.

The statistical data shows that the probability of the deviation being due entirely to chance is less than 5%. This means that some unknown outside factor must be working to cause the buttered side to land down. There is also a distinct possibility that the sample size or number of trials was too small to allow for valid results.

12. • **Textbook question 6:** Notice in the question that the parent plants are not described. Since the F_1 generation has both tall and short plants, there are two possibilities.

Assume $Tt \times tt$; then 50% of the offspring should be tall and 50% of the offspring should be short.

$$X^2 = \sum \frac{(O - E)^2}{E}$$

$$X^2 = \sum \frac{(450 - 500)^2}{500} + \frac{(550 - 500)^2}{500}$$

$$= 5.0 + 5.0 = 10.0$$

	<i>t</i>	<i>t</i>
<i>T</i>	<i>Tt</i>	<i>Tt</i>
<i>t</i>	<i>tt</i>	<i>tt</i>

It was not due to chance alone. 10.0 is greater than 6.635 on the line for X^2 values for two classes. So the probability is less than one that the deviation is due to chance alone.

Assume $Tt \times Tt$; then 75% of the offspring should be tall and 25% of the offspring should be short.

$$X^2 = \sum \frac{(O - E)^2}{E}$$

$$X^2 = \sum \frac{(550 - 750)^2}{750} + \frac{(450 - 250)^2}{250}$$

$$= \frac{(-200)^2}{750} + \frac{(200)^2}{250}$$

	<i>T</i>	<i>t</i>
<i>T</i>	<i>TT</i>	<i>Tt</i>
<i>t</i>	<i>Tt</i>	<i>tt</i>

53.3 + 160 = 213.3, clearly indicating that this deviation would not have happened because of chance. 213.3 is well off the X^2 value scale for cases where there are only two classes as in this case, tall and short.

Section 2: Activity 1

1. A predator gains energy and matter with the food that it consumes.
2. Energy flows through the organisms in an ecosystem and the matter cycles. Energy must be continually added to maintain an ecosystem. Energy constantly enters the biosphere from the sun. Matter being of limited quantity in the biosphere must be recycled.
3. As energy is constantly being used and lost, the number of predators should be less than the number of prey organisms that surround them. That is why you find few situations where an animal has one exclusive food source.
4. The lynx population is very much tied to the hare population. As the number of hares increases, it is soon followed by an increase in the lynx population.
5. Yes, the lynx population exerts pressure on the hares. From the graph it appears that as the lynx population increases to a peak, the hare population soon declines.
6. As the population of the prey species increases, the number of the predatory species will also increase. As the predatory species increases to a point where the extensive predation on the prey species reduces its numbers, then the numbers of the predators will fall correspondingly. As the numbers of predators falls, the numbers of prey can increase.

7. As the numbers of hares increase, the numbers of healthy lynx also increase. This will result in greater reproductive success in the **next** breeding season thus increasing the numbers of young that survive. It is interesting to note that very often the amount of fat present in the females determines the number of offspring generated. As studied earlier in this course, this is a function of hormonal control.
8. If this animal was not camouflaged it might become prey because it would be more visible, making it easier to locate.
9. The main principle behind camouflage is to make the individual difficult to locate. Another example of this principle is the stripes on a zebra. These do not offer the zebra any obvious camouflage. In a running herd, though, it becomes difficult to isolate an individual organism to attack. The herd is then self-camouflaging.
10. These strategies make the fawn more difficult to detect therefore increasing its survival chances.
11. Once again the more difficult it is to find a calf or fawn, the more difficult it would be to prey upon it. As the caribou cows and calves are moving constantly it would be difficult for a predator to keep track of all of the individuals in the herd.
12. Special colouration and behaviours increase an organism's chances for survival by reducing the probability of it being killed for food. These traits and behaviours are under genetic control. Those individuals that survive live to pass these traits to the next generation. There would be a higher frequency of these traits in the gene pool.
13. The warning colouration lets possible predatory organisms know that these individuals are capable of causing serious harm.
14. A fly with the same colouration would be treated in the same manner as the bees or wasps. This increases its chance of survival.
15. Predators learn very quickly that the butterflies are unpalatable and will then avoid them. The individual has lost its life, but more of that population will now survive because of decreased predation.
16. Colouration alone would not protect the monarch butterfly. It also required protection by the toxin. After an encounter with the toxic monarch butterfly, predators may avoid them. The viceroy butterfly only has to look like a monarch butterfly to be avoided.

Section 2: Activity 2

1. The moose and wolf patterns have shown changes in their populations as you would have expected. Increases in the prey population are followed by increases in the predator population.
2. The pattern of the population changes is a regular oscillation between high and low levels.
3. In both cases the cycle frequency appears to be thirty years.
4. The wolf population cannot grow until a healthy moose population is present. A healthy moose population supports a healthy wolf population. The wolves cannot increase their numbers until a large moose population is present. The wolves reproductive success then increases, resulting in the increase that is slightly out of phase and is lagging behind the prey.

5. The wolf populations have been severely depressed by early bounty hunting, and poisoning, as well as poisoning in the 1950s in an attempt to control rabies. The moose population may have been affected by over hunting on a number of occasions.
6. Logging removes mature forest and earlier growth stages. Logged areas may favour populations of deer, moose, and elk. As a result the wolf population may increase with the availability of prey. The increased wolf population has a greater effect on the caribou population as they are easier to kill than other prey and have less habitat available to disperse into to avoid predation.
7. Answers will vary but there are two basic solutions. One would be to reduce the amount of wolves thereby reducing the amount of predation on the caribou. There should then be a recovery in the caribou population. As time passes though, the wolf population will grow due to the increased food available. The problem will not be solved, but becomes one of continuous management. The other solution would be to stop all logging in the area. While it may be a possible solution, it is not feasible as the region depends on the timber for its economic existence.
8. The killing and removal of wolves is a very controversial issue. There are many people who are opposed to this type of management plan. But if the wolves are not controlled, the caribou population may decrease to a point where it will not be able to rebound. The removal of the wolves will also allow the other ungulate (deer) populations to grow unchecked causing damage to the habitat. The situation is now at the point where the entire ecosystem must be managed. Notice the relationship between trees, lichens, caribou, moose, deer, wolves, and humans.
9. The population peaks every ten years.
10. The lynx and the hare showed a similar variation.
11. The sudden drop in population may be due to extreme weather conditions or starvation brought on by overpopulation and reduction in the food supply.
12. The pest problem suddenly increased because the pesticide used also removed the predator species. Most prey species have a higher reproductive capacity and the numbers increase much more rapidly than the predator species. With no predators present to keep their numbers in check, a population explosion occurred.
13. The habitat that surrounds the crop provides an environment for the predator species. Removal of this habitat effectively prevents the small numbers of predators from increasing their numbers in response to the prey.
14. The populations of the hare peak every eight to ten years.
15. The food availability determines how rapidly the hare population increases as well as the hare's ability to reproduce very quickly.
16. The regrowing forests are very dense and they supply a great deal of cover for the hares that protects them from predation.
17. By being able to change its colouration pattern to match that of the environment, the hare increases its ability to avoid predation thereby increasing its chance for survival.
18. If the hare population is artificially reduced, the animals that prey upon it would be severely affected. As the hare is the major food source for owls, coyotes, and lynx, these animal populations would be depressed.

- 19. The health of the predator is a major factor in its ability to reproduce. If the predators are not in a well-fed state, they will not be able to produce a large number of offspring. The increasing hare population provides the predators with an abundance of food. They now have a much more successful reproductive season.
- 20. The sudden die-off of hares leaves the predators with less food. The competition between these individuals for the limited food available results in an increased mortality of predators.
- 21. The main focus of your paragraph should link the number of hares to the number of predators. If the hares are low in numbers, the predators’ (lynx, coyote, owls) numbers will also be very low. The hare is an extremely important link in the food chain transferring the energy captured by the plants to the carnivores. If the hares are not available, the predators must seek out other less-available prey. If this is the case, the predator populations will drop.

Section 2: Activity 3

- 1. Gause’s principle states that no two species can occupy the exact same niche at the same time without stress factors causing one of the species to be reduced in numbers or eliminated. The Gaussian principle is represented by interspecific competition.
- 2. The population density of both species decreased because the nutrient supply must be shared when the two populations are living together. The purple line falls to zero because that organism was unable to compete for the nutrients with success.
- 3. One species of paramecium would have died out due to its inability to obtain food, cope with the stress of competition for space, and find a suitable breeding area.
- 4. The kind of competition represented within a population is intraspecific competition.
- 5. Intraspecific competition is a force that drives natural selection by allowing survival of only the individuals who are able to cope with the stresses of competition for food, space, and breeding areas.

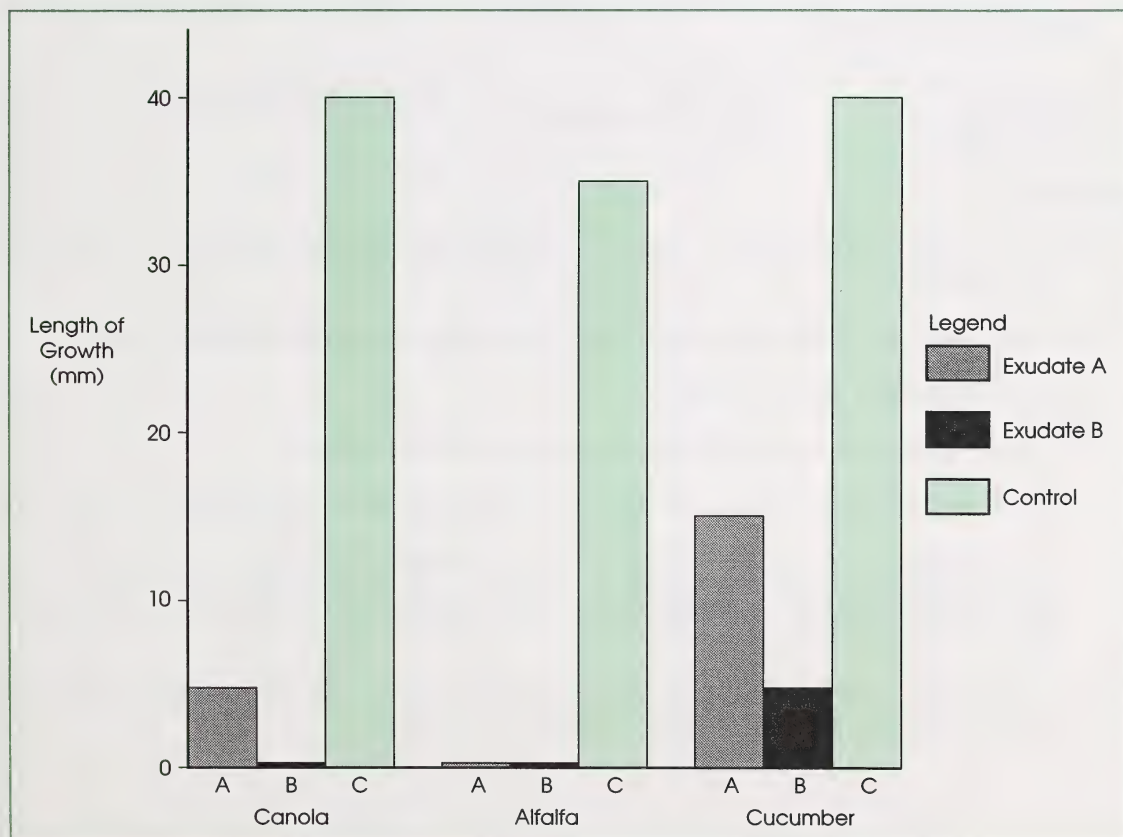
6.	Destruction of Habitat for the Purpose of Food Production	
	Point	Counter Point
	• increased food supply for a healthier population of humans • decrease in death rates • income for the farmer • export commodity for the country • increased standard of living	• decreased food supply for the animals in the area • increase in competition between species in the area • possible extinction of species due to loss of habitat • loss of natural area • loss of gene pool diversity

- 7. The mice would have to broaden the base of their foraging efforts or turn to alternative food sources that they could obtain more efficiently.
- 8. • **Review question 24:** Mutualistic relationships are beneficial to both organisms involved. Pollination is an example of a mutualistic relationship. Bees get access to a food source, and flowers have the pollen transferred to other flowers, allowing them to reproduce. Commensalism is a type of symbiotic relationship where one organism benefits, but the other is not affected in any way. The example of sharks and remoras is a good illustration.

- **Review question 25:** A predator differs from a parasite in that the predator kills its source of food. A coyote kills a rabbit for food. A parasite may harm its host when it takes nutrients from it; however, it does not want to kill it and lose the source of nutrients. A tapeworm living in the digestive system of a cat absorbs nutrients and reduces the nutrients available, but does not take enough to kill the cat.
9. a. Both the baleen whale-plankton and the penguin-plankton relationships are examples of predator-prey because the plankton's life is being ended. The penguin-baleen whale relationship is an example of interspecific competition because both are searching for the same food source.
 - b. Zebra benefit from the ostriches' presence because the ostriches will alert them if any danger arises. The ostriches, however, receive no benefit from the relationship. This is an example of commensalism.
 - c. The larger fish and the clown fish are in a predator-prey relationship because the chase would signify a search for food. The relationship between the clown fish and the sea anemone is one of commensalism. The clown fish benefits by obtaining protection in the poisonous tentacles. The anemone is neither helped nor harmed. The relationship could be mutualistic if the clown fish attracted other fish which would be stung, killed, and eaten by the anemone.
 - d. The coyote-rabbit relationship is a predator-prey relationship because the rabbit is a food source for the coyotes. The two coyotes are experiencing intraspecific competition. They are both of the same species searching for the same food supply. Remember that in this case the forces of natural selection are occurring.
 - e. In this interesting example of relationships you should have found three interactions. First, is the relationship between the ant and the acacia tree. The tree benefits from the cleaning of its leaves while the ant benefits by having a home in the dead limbs of the tree. Neither is harmed and both benefit, which makes the relationship mutualistic. Second, the ant and scale bug also have a mutualistic relationship. The scale bug is provided with a home near its food source and the ant is provided with a food source in the sweet secretions of the scale bug. Finally, the only relationship that is harmful is that between the scale bug and the acacia tree. The scale bug is a parasite on the host acacia tree.
10. Results of germination and growth of seeds might look like the following sample. Your data will vary.

Germination							
Seed Type	24 h		48 h		72 h		Average Length of Root (mm)
	No.	%	No.	%	No.	%	
Can A	0	0	6	20	8	27	5
Can B	0	0	0	0	0	0	0
Can C	10	33	27	90	30	100	40
Alf A	0	0	0	0	0	0	0
Alf B	0	0	0	0	0	0	0
Alf C	7	23	21	70	26	87	35
Cuc A	0	0	20	67	28	93	15
Cuc B	0	0	10	33	24	80	5
Cuc C	3	10	30	100	30	100	40

11. a. Which exudate will have the strongest effect on the germination and growth of seed?
- b. If an allelopathic response is taking place, then the seeds tested will show reduced germination and growth. It is impossible to predict which exudate will have the greatest effect because the identity of the exudates is unknown.
- c. The sterile technique was used to prevent any bacteria or fungi from interfering with the germination of the seeds or slowing their growth. The only variable being tested was the effect of the exudates.
- d. A control was used to compare the normal germination rates and growth with the germination and growth rates as affected by the exudates (manipulated variables).
- e. In any experiment the more trials you put into the data, the lower the error and the more valid the results.
- f. Exudate B proved to be the most effective at preventing the germination and growth of the seeds. It was capable of totally preventing any germination in the canola and the alfalfa. Most cucumber seeds germinated but Exudate B was able to severely stunt their growth as compared to Exudate A and the control.
- g. This is a sample of what your graph might look like.



Section 2: Follow-up Activities

Extra Help

1. The three adaptations that this moth shows are colouration that matches the tree bark, behaviour to seek out this pattern to hide on, and behaviour to not move during daylight hours. The moth also has a shape and posture that help it to hide.
 2. The high frequency for these traits can be explained by natural selection. Individuals that do not exhibit these favourable characteristics suffer greater predation reducing their chances of reproducing. The traits that these less-adapted organisms show are removed from the gene pool by predation.
 3. The adaptive behaviour of the mites is to seek out flowers that match their colouration pattern in order to camouflage themselves. They may also select the sharp spines of the flower for protection.
 4. The inherited shapes of these insects reduces their predation as predators learn to avoid them.
 5. The fly and the moth gain protection by mimicking organisms that are dangerous or foul tasting. This ability to look like another organism is a very useful method to increase the chances of survival.
 6. The organisms shown in these slides increase their chances of survival by having shapes and body parts that confuse or scare off predators.
7. a. commensalism d. mutualism g. intraspecific competition
b. predators e. interspecific competition
c. parasitism f. prey

Enrichment

1. a. The raccoons are destroying large numbers of nesting sea birds. Over 80% of some populations have been reduced.
b. The raccoons were brought to the islands for fur-farming then released when the industry failed.
c. Sewer rats also prey on nesting birds.
d. Animal rights groups may protest against trapping and killing the raccoons.
e. For elimination of raccoons: If raccoon numbers are not reduced, sea bird colonies will be destroyed.

Against elimination of raccoons: Predation is a natural behaviour. It's not the raccoon's fault that there are many birds to eat. Some other solution should be found. As sea bird numbers decrease, the raccoon population should also go down unless raccoons turn to other food sources. The populations of predator and prey should be allowed to cycle naturally.

- f. The ethical issue is that human actions caused the problem so humans are responsible for a solution. The solution may now require the killing of large numbers of raccoons.

2. From the observations presented it appears that the wolf and moose populations, once having become established, are starting to exhibit normal predator-prey relationships. That is, when the prey reached a critically low level, it was no longer able to support the existing population level of predators. The wolf population crashed as expected. The moose population in response to this reduced level of predation should increase near to its former numbers. In time the wolf population should recover and the pattern of oscillations should continue unless something major disrupts it.
3. The statement is correct. If the predator was not present, one prey species may outcompete many of the other species in a community. This would result in a loss of diversity. As mentioned in the *Equinox* article, the sea otters prevented the sea urchins from destroying the kelp forests. This maintained the habitat for all the other species that depend on the kelp forests for their home. As the sea otter continues to reestablish itself in its previous ranges, one can expect an increase in the diversity of species along the Pacific coastline. A keystone predator is good for diversity in an ecosystem.

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